URS

October 25, 2010

Mr. Vance Jackson
North Carolina DENR
Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605
919-508-8545

Re: Phytoremediation System Preconstruction Report
Former Seaboard Chemical/ Riverdale Drive Landfill Project
Jamestown, North Carolina

Dear Vance:

On behalf of the Seaboard Group II and the City of High Point, URS is transmitting three (3) hard copies and three (3) CDs that contain the Phytoremediation System Preconstruction Report for your review.

Please contact Jim LaRue if there are any questions or comments.

Sincerely,

Ari M. Ferro, PhD
URS
Principal Environmental Scientist
Phytoremediation

Enclosure
cc: Jim LaRue - Southwestern Environmental Consulting, Inc.
Gary Babb - Babb & Associates, P.A.
Randy Smith – American Environmental
Tom Wilson - ERM NC, PC

R E P O R T

FORMER SEABOARD CHEMICAL/ RIVERDALE DRIVE LANDFILL PROJECT

PHYTOREMEDIATION SYSTEM PRECONSTRUCTION REPORT

JAMESTOWN, NORTH CAROLINA

SEABOARD GROUP II &
CITY OF HIGH POINT, NORTH CAROLINA

October 2010

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

This document describes the objective and final engineering design of the phytoremediation system on the City of High Point Riverdale Drive Landfill site. The phytoremediation system will function in conjunction with the constructed treatment wetlands and the physical treatment system (PTS) to treat contaminated groundwater and landfill leachate at the site. Effluent from the treatment wetlands containing 1,4-dioxane will be used to drip-irrigate the phytoremediation system, which is made up of approximately 30 acres of tree stands divided into 15 irrigation zones on the west and east lobes of the Landfill. The objective of the system is to transpire the irrigation water and remove the 1,4-dioxane via phytovolatilization. In this report, the treatment mechanism is explained, as well as how the design of the tree stands and the drip-irrigation system will potentiate the mechanism. The results of preliminary studies, including greenhouse and pilot-scale phytoremediation studies and soils characterization assessments, were the basis for the design of the phytoremediation system.

A water balance needs to be maintained in the system in order for phytovolatilization to be fully effective as well as to prevent unacceptable percolation of irrigation water through the landfill soil cover and into the underlying landfill waste layer. Water input from irrigation and precipitation needs to be balanced against water exiting the system through evapotranspiration. The primary mechanism for water use by the mature phytoremediation system will be transpiration by the tree stands, which will be proportional to the rate of evapotranspiration (ET). Performance monitoring of the water balance will be based on data from soil moisture sensors in each irrigation zone. The data from these sensors will provide zone-specific and soil-specific feedback on the irrigation schedule, and will be the basis for automatically determining whether or not to proceed with irrigation. If deep drainage in a given irrigation zone is imminent, based on the known water holding capacity of the landfill cover soils, irrigation for that zone will be halted.

Water balance estimates for a best-case scenario indicated that during several weeks in winter the water input may exceed the transpiration rate. Therefore, when the monitoring system indicates that soils in all of the irrigation zones have reached their water-holding limit, the Master Controller will have the capability to shut down the irrigation of the tree stands. Under this condition, the Controller would divert the water to and automatically activate the PTS.

2.1 BACKGROUND

A plume of contaminated groundwater originates from the former Seaboard Chemical site, as well as from the Riverdale Drive Landfill. The plume contains chlorinated volatile organic compounds (cVOCs) as well as 1,4-dioxane. In September 2005, the North Carolina Division of Waste Management (NCDWM) approved the conceptual design of a remedial action system at the former Seaboard Chemical/ City of High Point Riverdale Drive landfill site (the site) in Jamestown, North Carolina. In order to protect the surface water quality of Randleman Lake, long-term containment of the plume will be required (i.e., 30 years or longer).

A series of groundwater recovery wells, pumping at the combined rate of approximately 50 gallons per minute (gpm) year round, will hydraulically control the plume and prevent exceedences to the surface water standards in the Randleman Reservoir. The existing leachate recovery system will continue to collect landfill leachate from limited portions of the landfill. Recovered groundwater and leachate will pass through an on-site physical treatment system (PTS), and this system will be used in the short term to provide treatment of extracted ground water and leachate. The PTS consists of a metals removal system, an air stripper (to remove cVOCs) and an advanced oxidation ("PhotoCat®[1]") system to remove 1,4-dioxane. The effluent from the PTS will be discharged to the Eastside Wastewater Treatment Plant under a Wastewater Discharge Permit issued by the City of High Point. The physical treatment process and engineering design were presented in a separate preconstruction report submitted to the North Carolina Division of Waste Management in December 2009.

In the long term, in order to incorporate sustainability into the site remediation, the recovered groundwater will be routed to a two-component natural treatment system. The first component will be a constructed wetland for the removal of cVOCs. The wetland will be an approximately 2.0 acre upward vertical flow system that will remove cVOCs via anaerobic dechlorination. It is expected that 1,4-dioxane will pass untreated through the wetlands system. The second component of the natural treatment system is the phytoremediation system. The objective of the phytoremediation system, located on the closed City of High Point Riverdale Drive Landfill (Landfill), is to remove 1,4-dixoane from recovered groundwater.

Initially, there will be a period of several years during which the phytoremediation tree stands and the wetland plants will be maturing and only capable of handling a portion of the design flow. During this period, the achievable capacity of the phytoremediation system will be utilized, and the PTS will be used to provide supplemental treatment of extracted ground water and leachate. Long-term, the physical treatment system will also provide a "backup" to the natural system should the need arise.

[1] PhotoCat is a registered trademark of Purifics ES, Inc. of London, Ontario, Canada.

2.2 OVERVIEW OF PHYTOREMEDIATION SYSTEM

The phytoremediation system consists of stands of conifer and hardwood tree species established on approximately 30 acres of cover soils on portions of the west and east lobes of the Landfill (Figure 1). Effluent from the constructed wetlands containing 1,4-dioxane (2 to 3 mg/L) will be routed to a drip-irrigation system for the tree stands. The trees will use the irrigation water via transpiration and take up the dissolved 1,4-dioxane. The 1,4-dioxane will be phytovolatilized, a process in which the compound is taken up by the roots, translocated to the shoots, and exits the plant via the transpiration gas. Once in the atmosphere, the 1,4-dixoane will be rapidly photo-degraded into harmless decomposition products.

In order for the 1,4-dioxane treatment process to be effective, transpiration by the tree stands must use substantially all of the irrigation water that is not removed by other evapotranspiration mechanisms (e.g., evaporation and uptake by other landfill vegetation). Therefore, a water balance will need to be maintained. Water entering the phytoremediation system via irrigation and precipitation must be balanced against the rate of water leaving the system via evapotranspiration. When the phytoremediation system is fully mature (the tree stands have completely closed canopies), most of the water leaving the system will be due to transpiration from the tree stands, with only a minor component removed through surface evaporation or uptake by surface vegetation (e.g. weeds and grasses).

Preliminary studies were carried out including those assessing plant uptake of 1,4-dioxane, the quality of Seaboard groundwater and landfill leachate, the characteristics of landfill cover soils, and a pilot-scale phytoremediation study (Appendices A and B). The results of these preliminary studies were used to design the 30-acre phytoremediation system including the irrigation control and monitoring system. The results of the preliminary studies indicated that the irrigated phytoremediation system could be effectively managed and that phytovolatilization of the 1,4-dioxane added via the irrigation water could be achieved.

A pilot-scale phytoremediation study was conducted on the west lobe of the Landfill to test the feasibility of the 30-acre phytoremediation system. The study consisted of small plots of trees that were drip-irrigated with groundwater obtained from recovery well PW-DR1 containing 2 to 3 mg/L 1,4-dioxane. The principal objective of the pilot study, conducted during the 2010 growing season, was to assess the efficacy of the phytovolatilization treatment mechanism. A secondary objective was to assess the tendency of the inorganic components in the irrigation water to accumulate in the root-zone soil or the plant tissue. The following are some of the main aspects and results of the pilot study:

- Tree species included loblolly pine, Japanese black pine, Virginia pine, willow oak, Chinese elm, and hybrid poplar.
- All of the species were very effective at 1,4-dioxane uptake.
- Within the limits of sensitivity for the study methods used, we can state that greater than 80% of the 1,4-dioxane added to the tree plots via drip-irrigation was removed by phytovolatilization, biodegradation in the soil, or volatilization from the soil surface.
- The accumulation of salts in the root-zone of the trees appeared to be minimal due in part to their tendency to leach into deeper soil layers (See Appendix A).
- The trees remained healthy although certain inorganic components of the groundwater, such as manganese, accumulated in the plant tissue. However, these substances will be removed in a groundwater pre-treatment process for the trees in the 30-acre phytoremediation system.

4.1 TREE STANDS

The 30-acre phytoremediation system is made up of approximately 13,000 trees established on portions of the west and east lobe of the City of High Point Landfill (Figure 1). The trees are established on the landfill cover soils that behave as loam or sandy loam soils and that are nominally 3 to 5 feet thick. Starting in spring 2007, trees were planted as bare-root seedlings, and there have been additional plantings in subsequent years to replace dead trees. In anticipation of the installation of the irrigation system (started in fall, 2009), the tree stands were divided into 15 zones, each approximately 2-acres in size. The trees were planted in rows 10 feet apart, and the trees within a row are roughly on 10-foot centers (approximately 435 trees per acre).

4.1.1 Tree Species

The conifer and hardwood species currently established within various zones of the phytoremediation system are listed below. Species selection was based in part on results of a greenhouse study assessing plant uptake of 1,4-dioxane and tolerance of the groundwater (summarized in Appendix A).

- Conifers
  - Loblolly pine (*Pinus taeda*)
  - Pond pine (*Pinus serotina*)
  - Virginia pine (*Pinus virginiana*)
  - Japanese black pine (*Pinus thunbergii*)
  - Eastern redcedar (*Juniperous virginiana*)
  - Bald cypress (*Taxodium distichum*)

- Hardwoods
  - Kentucky coffee tree (*Gymnocladus dioicus*)
  - Common hackberry (*Celtis occidentalis*)
  - Chinese elm (*Ulmus parvifolia*)
  - Mulberry (*Morus alba*)
  - Hawthorn (*Crataegus phaenopyrum*)
  - Black locust (*Robinia pseudacacia*)
  - Green ash (*Fraxinus pennsylvanica*)

4.1.2 Planting Zones

The distribution of the tree species within the various zones is outlined in Table 1. The locations of the zones are shown in Figure 1 and are either on the west lobe (W) or east lobe (E). There are 10.5 zones on the west lobe and 4.5 zones on the east lobe (zone 11 is divided between the two lobes). Twelve zones contain conifer species and three zones contain hardwood species. Hardwoods are in zones 5, 10, and 13 (approximately 6.3 acres), and the other zones (approximately 23.7 acres) all contain conifers. Bald cypress is planted in small, low-lying, wet areas in certain conifer and hardwood zones to prevent water from accumulating in those areas. The bald cypress trees are only intended to control potential accumulation of stormwater and are not irrigated.

4.1.3 Water Balance Estimates

Water balance estimates were performed for idealized tree stands of similar area and composition as those in the phytoremediation system and established at an ideal site with the same climatic factors as exist in High Point, NC (Appendix C). The tree stand would receive good quality irrigation water at the rate of 50 gpm year round (25.9 million gallons per year).

The water balance estimates for the idealized tree stand were carried out for years with average precipitation (30-year averages) as well as for the wettest and driest year since 1979 (Appendix C). The results of these hypothetical estimates were that even for the idealized tree stand, during certain weeks of December, January and February for an average year, about 2.1 million gallons of the irrigation water could not be used by the stand. Thus, in order to maintain a water balance, a portion of the irrigation water would need to be diverted away from the stand. This volume would be increased to 3.7 million gallons during the wettest year and reduced to 1.3 million gallons during the driest year.

Certain portions of the actual phytoremediation system on the Landfill may never achieve the transpiration rates of the idealized stand, even when mature. As outlined in Appendix C, plant stress may limit transpiration rates. Plant stress could potentially result from any of several factors such as salinity accumulation in the root zone, nutrient imbalances created by Landfill cover soil factors or derived from compounds in the irrigation water, or tree species-specific factors. The water balance analyses for the idealized system indicate that the PTS may be needed in the future to treat the groundwater and leachate that the natural system will not accommodate.

4.2 IRRIGATION SYSTEM

The phytoremediation system will be drip-irrigated with wetland effluent using a system that is divided into 15 irrigation zones, and that will be activated one zone at a time year round (Figure 1, Table 2). The irrigation zones range from 1.6 to 2.4 acres in area (average approximately 2 acres per zone). The system has 3 hardwood zones that will be irrigated during the growing season (mid-April through mid-October). The other zones (approximately 23.7 acres) contain conifers species that will be irrigated during the winter months and during the growing season if necessary to maintain a water balance. The drip-irrigation system will also be used to apply soluble nutrients to the trees, as needed, a process termed *fertigation*.

The following bulleted paragraphs describe the main components of the system. Detailed engineering diagrams are provided in Appendix D. Specifications for the main components are included in Appendix E.

- ***Drip-Irrigation Lines.*** Each irrigation zone has multiple Netafim Uniram Drip-Lines laid out on the ground surface and spaced 10 feet apart. The lines run down the rows of trees and are within a few inches of the tree stems. Drip-emitters in the lines are spaced from 1.17 to 1.50 feet apart, with drip-rates either 0.42 or 0.61 gallons per hour (gph) (Table 2). The measured flow rates per zone range from

40 gpm in Zone 4 to 59 gpm in Zone 8. The drip-lines within a given zone are attached to 2-inch sub-main water line installed in 2 to 3-foot deep trenches.

- ***Field Valves***. In each irrigation zone, one hydraulic value controls the water supply to the 2-inch sub-main water line in that zone. The valves are inside insulated valve boxes supported by 2 X 4 foot concrete pads. Three-inch main water lines and hydraulic lines are connected to each field valve and are installed together within 2 to 3-foot deep trenches. The water supply lines and hydraulic lines lead to the pump station. There are separate valves for zones 11a and 11b. These valves are activated together.
- ***City Water Supply***. Three-inch main water lines from the west and east lobes of the landfill are connected to a water distribution system inside a pump station (currently in a converted Sea-Land Container). Within the pump station, the water lines are connected to a water meter, a pair of backflow preventers, and finally to a nearby city water meter box.
- ***Hydraulic Control Lines.*** Hydraulic control lines from each field valve are connected to a series of hydraulic solenoids mounted on a bracket inside the pump station. A hydraulic control water line is connected to each solenoid and is supplied with city water.
- ***Fertigation System.*** Outside of the pump station is a 2,500 gallon fertilizer tank connected to a fertilizer pump and a hydraulic valve by a one-inch line. The fertilizer valve is controlled by a hydraulic solenoid supplied with city water like the other solenoids. Nutrient solution from the fertilizer valve is connected to a fertilizer meter, and is then injected into the three-inch water main line.
- ***NMC-PRO Controller.*** The controller is mounted inside the pump station. At the time of report submittal, it is used to control the irrigation and fertigation system and maintains a log of all functions including water run times and flow rates to each zone as well as irrigation and fertigation schedules. When the PTS is constructed, the Master Control System will perform these functions.

The NMC-PRO Controller keeps a record of the flow rate for each irrigation zone. Flow rates have been established based on the size and number of emitters (Table 2). These flow rates will be checked regularly during the time the controller is being used, especially after field activities such as mowing or weed control. The drip-lines will be promptly repaired when necessary.

Based on analysis of composite tissue samples from species in the various irrigation zones, an appropriate nutrient solution will be used to fertigate the irrigation zones in subsequent growing seasons (Section 7.2.3). The fertilizer tank and lines will be flushed out at the beginning of the season and the tank filled with solution as needed. The cumulative readings on the fertigation meter will be checked on a routine basis and correlated with the levels of nutrient remaining in the tank.

5.1 OBJECTIVES AND OVERVIEW

A system has been designed to monitor and control the irrigation system (Appendix F). The parameters that will be monitored are the irrigation rate and soil moisture content in each zone as well as ET and precipitation (Table 3). For phytovolatilization to be fully effective a water balance needs to be maintained in the system: water input from irrigation and precipitation needs to be balanced against water exiting the system. The Master Controller is the key component of the monitoring and control system because it will ensure that a water balance is maintained and that unacceptable drainage of irrigation water into the waste layer of the landfill does not occur.

The Master Controller will receive two types of data input:

- Data from the environmental sensors (soil moisture sensors and weather station instrumentation). This data will be input daily
- Programming instructions from the Operator. These instructions will be input once per quarter.

Based on that information, the Master Controller will automatically perform two related functions:

- It will determine the volume of irrigation water that can be routed to the different irrigation zones while maintaining a water balance.
- It will shut down irrigation to specific irrigation zones if necessary to prevent leaching of irrigation water into the waste.

The key performance monitoring parameter for the phytoremediation system is that irrigation for a given irrigation zone will be discontinued if the soil moisture exceeds the "set point" for that zone. It will not be re-started until, as a result of transpiration, the soil moisture drops below the set point.

5.2 DESIGN

Details of the design are presented in Appendix F. The monitoring system will consist of stations in each irrigation zone containing sets of three soil moisture sensors (installed at 12, 30 and 48 inches bgs). The most common moisture sensor used in the system will be the Decagon 10 HS Probe (Figure 2). The nests of moisture sensors will be installed within about 1 foot (horizontal distance) from a drip-irrigation line. The stations will be grouped into pairs (primary and secondary stations) that communicate via a buried cable in conduit. The primary monitoring station will retrieve data from the secondary station and report the data to a west or east lobe Repeater via spread spectrum radio. The Repeaters communicate with the Master Controller, which monitors and logs all data, controls irrigation to all the zones, administers alarms, and relays the information the PTS. The Master Controller data are available to other computers via a cellular IP address.

5.2.1 Master Controller Input

Data inputs for the Master Controller are of two types:

- ***Data from environmental sensors.*** The Master Controller receives daily data from soil moisture sensors located in each zone at three different depths (12, 30 and 48 inches bgs). It also receives daily weather station data from which it can automatically calculate ET and estimate precipitation. The rate of transpiration by the tree stands is proportional to ET (see, for example, Figure A1 in Appendix A).
- ***Programming instructions from the Operator.*** The Operator will program the Master Controller once per quarter with estimates for stand transpiration rates for the various zones (at a given ET). The rates of transpiration will be a function of stand maturity and the tree species. The Operator will also program the Master Controller with the irrigation "set points" for each irrigation zone. The irrigation set point is the soil moisture above which drainage will occur.

5.2.2 Master Controller Functions.

The Master Controller will have two main functions:

- ***Irrigation volume per zone.*** Information input will allow the Master Controller to calculate the volume of irrigation water that can be routed to each irrigation zones while maintaining a water balance. Water input from irrigation plus precipitation will be balanced by transpiration.
- ***Cessation of irrigation to specific zones.*** The Master Controller will automatically compare the soil moisture content in each zone with the irrigation "set point" for that zone. If the moisture content exceeds the set point, irrigation to that zone will be discontinued until transpiration by the trees dries out the soil to a sufficient extent. The Master Controller will therefore prevent the zones from being over-irrigated which could result in irrigation water leaching into the waste layer. If all of the irrigation zones are shut down, the Master controller will activate the PTS.

5.3 RATIONALE FOR THE DESIGN

The transpiration rates of the tree stands are proportional to ET and therefore fluctuate from week to week. During hot, dry periods the stands will use more irrigation water, and during cool, wet periods the stand will use less. However, at a given state of maturity, the rate of water use will also depend on the trees species. The volume of irrigation water routed to the tree stands therefore will be a function of ET and precipitation, as well as the state of maturity and species of the stand. Programming instructions from the Operator and data from the weather station will allow the Master Controller to automatically modulate the volume of irrigation water routed to each stand. Thus, the irrigation schedule will be responsive to environmental conditions as well as to stand-specific factors. The ET can increase very rapidly from day to day and rain events can be sudden, and therefore the data from the weather station can provide the Master Controller immediate predictive data. This enables the Master Controller to use irrigation water to the fullest extent possible.

Weather station data are important in the design because significant changes in data from soil moisture probes at 2 ft bgs will lag several days behind sudden changes in ET and precipitation. It can suddenly get hot, increasing transpiration, but this increase in water use will be reflected by significant changes in soil moisture at 2 ft bgs only after several days. As the season progresses from May through July, and the ET increases, the Master Controller will automatically steps up the irrigation (i.e., ET is used as a predictive tool). If it rains, the Master Controller will reduce irrigation to maintain the water balance. However, the data from the soil moisture sensors can override the data from ET and precipitation and thereby act as a safety check on the system. Soil moisture data will ultimately be the deciding factor on whether to irrigate or not.

Soil moisture sensors (further described in Appendix F) will be strategically located within each zone to provide representative soil date for the entire plot and across the landfill. This includes placing some sensors in low-lying wet locations and others in dryer locations, the goal being to achieve a composite representation of a zone's soil moisture conditions.

On a macro scale, the Master Controller will keep track of the cumulative water balance, for each zone. The Master Controller has the ability to reduce irrigation to any given zone if the water balance data suggest that water input is exceeding pre-set parameters. The extra irrigation water will automatically be diverted to another zone that is able to accept more water. This capability provides maximum flexibility by allowing irrigation water to be spread over many zones such that given zone is not arbitrarily irrigated up to the irrigation set point. The monitoring of the water balance zone by zone provides an excellent check of the soil moisture sensors in that zone. A drying water balance will suggest that soil moisture should be decreasing, and a wetting water balance will suggest that soil moisture should be increasing. These conditions will be continually logged, and used for Operator alarm alerts.

5.4 IRRIGATION "SET POINT"

Soil moisture content at 12, 30 and 48 inches bgs will be compared by the Master Controller to the Soil Water Characteristic Curves (SWCCs) for the specific zone (Appendix B). The Controller will be programmed with design "set points" for each zone that will be the percent volumetric soil moisture at -4 kPa soil suction (Figure B2). If the average soil moisture for the sensors at 12 and 30 inches bgs is greater than the set point, and the sensor at 48 inches bgs is in saturated soil, irrigation for the zone will be discontinued. Although the set points are different for each zone, the average set point across the 15 zones is 33.9%. Irrigation would be re-started once transpiration by the trees reduces the soil moisture content to less than the set point.

When the phytoremediation system is first irrigated with wetland effluent, the Operator will approximate the rate of water use for a specific zone at any particular time (e.g., May 1). During the first week of irrigation, the soil moisture will be continually monitored. If soil moisture appears to be climbing too fast, the volume of irrigation water routed to the zone would be decreased. Adjustments would be made in the irrigation schedule until a rough water balance is obtained. During the beginning stages of the project, the irrigation set points would be empirically refined. For example, the initial set points at

-4kPa may be adjusted to closer to -10kPa if it appears that the soil is becoming too wet based on the Operator's judgment.

During certain periods, the rates of transpiration by the tree stands may not be sufficient to keep up with the rate of effluent production by the wetland plus precipitation. This condition will be automatically detected by the Master Controller, and based on the soil moisture content in the landfill cover soils, the rate of irrigation will be automatically reduced or stopped. Wetland effluent will be routed to the PTS system and hence to the POTW. The PTS will automatically be cut off, and water again routed to the phytoremediation system, once transpiration has reduced the soil moisture content to acceptable levels.

5.5 CRITERIA FOR OPERATION AND COORDINATION WITH THE PTS

The criteria for the operation of the irrigation system will be based on data from soil moisture sensors in each irrigation zone. The data from these sensors will provide zone-specific and soil-specific feedback on the irrigation schedule, and will be the basis for automatically determining whether or not to proceed with irrigation. If deep drainage in a given irrigation zone is imminent, based on the soil water characteristic curves of the soils, irrigation for that zone will be halted.

Water balance estimates indicated that even in a best-case scenario, during several weeks in winter, the water input will exceed the transpiration rate (Section 4.1.3). The Master Controller will have the capability to automatically discontinue irrigation and activate the PTS when the monitoring system indicates that soils in all of the irrigation zones have reached their water-holding limit. Thus, the Master Controller will prevent the soil from becoming overly wet, leading to the deep percolation of irrigation water

6.1 LOCAL PERMITS FOR BACKFLOW PREVENTION AND ELECTRICAL SERVICES

The irrigation system for the phytoremediation system was connected to the City of High Point water supply following plans approved by City personnel. The physical connection includes the installation of the following equipment and certifications:

- *Equipment*: Two 2-inch reduced pressure valve assemblies (RPZs) to prevent backflow and/or potential contamination of the City water supply.
  - RPZ installed directly downstream of the water tap;
  - RPZ installed in pump house directly upstream of the fertigation pump.
- *Certifications*: RPZs were installed by a certified backflow specialist and tested (4/22/2010) as required by the manufacturer and the City. The installations were inspected by a City inspector, and a Letter of Compliance submitted to the City.

If any future modifications are planned for the irrigation system, the City will be notified for approval and/or re-inspection prior to starting work.

Electrical service on the landfill property will be provided by the City of High Point. Inspections prior to service start-ups associated with the irrigation control system will be performed by the City of High Point Electric Department.

6.2 EROSION AND SEDIMENTATION COTNROL

There are no earth disturbing activities associated with the construction of the phytoremediation system that require stormwater and erosion control permitting.

6.3 AIR PERMITTING

No air permits are required for the operation of the phytoremediation system. ERM performed an air regulation applicability determination for potential air emissions from the treatment of the groundwater by a remediation system. The potential VOC emissions from an air stripper were calculated to be 1.64 tons per year. The potential emissions from the natural treatment system would be expected to be less than or similar to the air stripper emissions. According to Title 15A North Carolina Administrative Code Subchapter 2Q (15A NCAC 2Q) Section .0102(c)(2)(E)(i), sources with emissions of VOCs (among other pollutants) with potential emissions less than 5 tons per year do not require a permit.

6.4 POST-CLOSURE CARE

A current post-closure plan, specific to the operations at the former Riverdale Drive Landfill, is on file with the NC Solid Waste Section.

6.5 DISCHARGE PERMITTING

Based on discussions with NCDWM personnel, no discharge permits are required for the operation of the phytoremediation system.

The objective of the monitoring and maintenance program in the early stages of the project (prior to irrigation with wetland effluent) is to have full complement of trees in each zone (roughly 435 trees per acre) and to have an optimal rate of growth and development. After irrigation with wetland effluent commences, the objective is to have long term stand viability. Meeting these objectives will require a robust program for monitoring and maintaining the tree stands.

7.1 MONITORING THE TREE STAND

The monitoring program will include three general classes of monitoring activities, visual inspection, plant tissue sampling/analysis and soil sampling/analysis.

7.1.1 Visual Inspections

Items in the visual inspection program include the following:

- Weeds: Monitor the extent of weed growth and competition with the trees. Establishment of intrusive grasses and weeds in the root-zone of young trees will be of special note.
- Herbivory: Monitor the functionality of the electric fence and evidence of deer, rodent, or other animal damage especially in the hardwood stands.
- Missing trees: A survey of missing trees in each zone will be carried out at regular intervals (no less than at the end of each growing season) The survey in the fall, prior to the dormancy of the hardwoods, will be important to determine the number of trees that need replacing.
- If needed, as indicated by visual inspection, a program to conduct plant tissue and soil analyses will be developed.

7.1.2 Plant tissue Analyses

The objectives will be to assess nutrient deficiencies and imbalances due to alkaline pH, effects caused by specific inorganic compounds in the soil, to judge the effectiveness of the fertigation program, and (after irrigation with wetland effluent is started) to assess potential nutrient imbalances cased by salt effects and ion-specific effects. Sampling will be performed semi-annually during the first two years after the beginning of irrigation and as necessary thereafter. During these sample events, composite samples will be taken from healthy and stressed trees of a given species within each of the Landfill regions. Samples will be analyzed for inorganic constituents and other parameters as necessary.

7.1.3 Soils Analyses

Routine soil sampling will begin after irrigation with wetland effluent is started. The objective will be to assess the rate of accumulation of salts in the root-zone soils and assess the potential need to leach salts from the root zones of the conifer stands. During the first two years, and as required thereafter, composite soil core samples will be taken from the root-zone soils from tree stands in each of the general classes (e.g., stands containing loblolly pine, Japanese black pine, eastern redcedar, and hardwoods). Soil samples will be taken in spring after cold weather and winter rains, and in the fall after intensive irrigation during the summer. Soil samples will be analyzed for inorganic constituents including bicarbonate (HCO_3), pH, electrical conductivity (EC), calcium (Ca), chloride (Cl), iron (Fe), magnesium (Mg), manganese (Mn), and sodium (Na).

7.2 MAINTENANCE OF TREE STANDS

The maintenance program will include weed control, fence repair, tree replacement, fertigation, and potentially amending the soil in specific areas. Monitoring data and visual inspections will provide guidance for the most effective fertigation and soil amendment protocols.

7.2.1 Routine Tasks

These tasks include fence repair and weed control. Weed control includes spraying with pre- and/or post-emergent herbicides as well as mowing/string trimming between the trees. One main objective is to prevent grass from becoming established within the root-zones (16 ft^2 area) at the base of the young trees. Herbicide application will be carried out promptly as needed to maximize the desired effect.

7.2.2 Tree Replacement

The rows should have trees spaced on at most 10 ft centers. The installed drip-irrigation system contains drip-emitters on set intervals (Section 4.2.1). Therefore, if trees are missing the 1,4-dioxane containing irrigation water would not be taken up and deep percolation would be possible. Missing trees will be replaced with bare root seedlings at the optimal planting time: missing conifers with loblolly pine and missing hardwoods with the most readily available hardwoods listed in Section 4.1.1. The use of tolerant species will help address the problems in specific areas such as Zone 3 (Appendix B, Section B2). For example, Virginia pine was planted in Zone 3 in spring 2010 and so far this species is out-performing other species in the zone.

In the event of a strategic tree removal (e.g. in a problematic stormwater area, to aid in weed control, etc.), the unused section of dripper line will be removed or replaced with blank tubing to prevent irrigation in areas without trees.

7.2.3 Fertigation

Nutrient deficiencies and imbalances can be addressed by fertigation using nutrient solutions specifically formulated for different broad areas of the tree stand. Up to three different nutrient solutions can be used by the fertigation system (Section 4.2.1). Fertigation will be used to optimize tree growth and maintain the health of the tree stand. However, depending on the effectiveness of the metals removal system in the PTS to remove manganese, the potential chlorosis resulting from manganese-inhibition of iron uptake may be prevented by the continuous addition of chelated iron to the irrigation water (Appendix A). The success of the fertigation approach during a given season will be judged based on the analysis of nutrient status in plant tissue samples the following spring during the initial period of irrigation (Section 7.1.2).

7.2.4 Soil Amendments

Based on ongoing analyses of soils and plant tissue, amendments may be added to soils in specific areas to increase stand productivity.

The primary objective for performance monitoring of the phytoremediation system is to provide verification that there will be no unacceptable migration of irrigation water via infiltration to the landfill waste cells or by surface runoff. In order to confirm the effectiveness of the phytoremediation system, the following steps will be carried out:

1) The phytoremediation system will be monitored during a 30-day field performance test period upon startup of the system;
2) The soil moisture monitoring data and irrigation operation records will be reviewed regularly, and;
3) The results of visual field inspections for surface runoff of irrigation water will be reviewed regularly.

The Operator must confirm during the field performance test period that the Master Controller is accurately correlating the soil moisture content at 12, 30 and 48 inches bgs with the programmed design "set points" for each zone. The key performance requirement is that if the average soil moisture for the sensors at 12 and 30 inches bgs is greater than the set point, and the sensor at 48 inches bgs is in saturated soil, the Master Controller will shut off irrigation for the zone. During the beginning stages of the project, the irrigation set points will be empirically refined. For example, the initial set points at -4kPa may be adjust to closer to -10kPa if it appears that the soils is becoming too wet based on the Operator's judgment.

In addition, a *Remedial Monitoring and Effectiveness Evaluation Plan* (RMP) has been prepared to monitor and assess the results and effectiveness of the overall ground water and surface water remediation program to be conducted at the Site. The RMP was submitted to the NCDWM in October 2009 as Appendix E of the *Remedial Action Preconstruction Report* that presented the engineering design of the physical treatment system and constructed wetlands. The October 2009 RMP presents plans for site-wide groundwater and surface water monitoring, and monitoring and evaluation of the groundwater recovery well network. The RMP will be expanded to include the assessment of the results and effectiveness of both components of the natural treatment system (the wetland and the phytoremediation systems).

In accordance with the Remedial Action Settlement Agreement (RASA), the major milestones of the project schedule and progress reporting for the construction of the phytoremediation system are summarized in Table 4.

The installation of the irrigation monitoring and control system is one task that remains to be performed (as of fall, 2010). A description of the system is provided in Section 5.2, and components are listed in Table 3. The system could be installed weather permitting in late fall, 2010, or spring, 2011.

The maintenance tasks for the operation of the phytoremediation system are listed in Table 5, and reference specific sections in this document. These tasks related to the irrigation and fertigation systems, the programming of the Master Controller, maintenance and monitoring of the tree stands as well as the management of the landfill cover soils to prevent erosion.

Professional Engineer (PE) Certification

Phytoremediation System General Site Plan, Drip-Irrigation System Plan, Engineering Design and Components

By means of this certification, I attest I am familiar with the engineering aspects of this report limited to the following report components:

- Section 2 – Introduction
- Section 3 – Summary of Results from Phytoremediation Pilot Study
- Section 4 – Design of the Phytoremediation System
- Applicable Tables and Figures
- Appendix A – Pilot Scale Phytoremediation Study
- Appendix B – Soil Water Characteristic Curves
- Appendix C – Water Balance for Idealized Tree Strands.

Further, I attest that the Report has been prepared in accordance with good engineering practices including consideration of applicable State and industry standards. By affixing my seal as a registered Engineer in the State of North Carolina, I verify the applicable components of this Report have been prepared by qualified individuals under my direct supervision.

Name of Engineer: Joshua Fell

Registration No.: 033187

Signature: ____________

Stamp: NORTH CAROLINA PROFESSIONAL SEAL 033187 10/25/2010 ENGINEER JOSHUA D. FELL

Date: 10/25/2010

Professional Engineer (PE) Certification

Phytoremediation System Controls, Irrigation, and Monitoring Plan, Engineering Design and Components

By means of this certification, I attest I am familiar with the engineering aspects of this report limited to the following report components:

- Section 4 – Design of the Phytoremediation System
- Section 5 – Irrigation System Monitoring and Control
- Section 8 – Performance Monitoring and Evaluation Plan
- Applicable Tables and Figures
- Appendix F – Irrigation Monitoring and Control System Design

Further, I attest that the Report has been prepared in accordance with good engineering practices including consideration of applicable State and industry standards. By affixing my seal as a registered Engineer in the State of North Carolina, I verify the applicable components of this Report have been prepared by qualified individuals under my direct supervision.

Name of Engineer: ERIC NESBIT Registration No.: NC 026217

Signature: Stamp:

NORTH CAROLINA
PROFESSIONAL
SEAL
026217
ENGINEER
ERIC C. NESBIT

Date: 25 OCTOBER 2010

1. Atchison, E.W., S. L. Kelley, P.J.J. Avarez, and J.L. Schnoor. 2000. Phytoremediation of 1,4-dioxane by hybrid poplar trees. Water Environment Research, 72, 313-321.

2. Donahue, R. W. Miller, and J. C. Shickluna. Soils, an Introduction to Soils and Plant Growth, 5th Ed., Prentice-Hall, 1983.

3. Ferro, A., M. Gefell, R. Kjelgren, D.S. Lipson, N. Zollinger, S. Jackson. 2003. Maintaining hydraulic control using deep-rooted tree systems. In: Advances in Biochemical Engineering Biotechnology, Special Volume: Phytoremediation, G.T. Tsao and D. Tsao (eds.). Springer-Verlag, Heidelberg, Germany, Vol. 78. 125-156.

4. Ferro, A.M., and C.E. Tammi. 2009. Irrigation of tree stands with groundwater containing 1,4-dioxane. Internat. J. Phytoremed. 11:1-16.

5. Parales, R.E., J.E. Adams, N. White, and H.D. May. 1994. Degradation of 1,4-dioxane by an actinomycete in pure culture. Appl. Environ. Microbiology, 60:4527.

6. Schaedle, M. F.C. Thornton, D.J. Raynal, and H.B. Tepper. 1989. Tree Physiology 5:337-356.

7. URS, 2009. Quarterly Report for the Phytoremediation Projects at the Seaboard Site (3rd Qtr., ’09). Prepared for Seaboard Group II and the City of High Point. Prepared by URS (A. Ferro), October 15, 2009.

8. URS, 2010a. Quarterly Report for the Phytoremediation Projects at the Seaboard Site (4th Qtr, ‘09), January 15, 2010. Prepared for Seaboard Group II and the City of High Point Prepared by URS (A. Ferro). Prepared for the Seaboard Group.

9. URS, 2010b. Quarterly report for the Phytoremediation Projects at the Seaboard Site (1st Qtr. ’10), Prepared for Seaboard Group II and the City of High Point April 15, 2010. Prepared by URS (A. Ferro). Prepared for the Seaboard Group.

10. URS, 2010c. Nutrient Status for Soils in the Full-Scale Phytoremediation System, Potential to Enhance Tree Growth Rates with Mineral Nutrients, Specific Recommendations. Prepared for Seaboard Group II and the City of High Point Prepared by URS (A. Ferro), June 18, 2010.

TABLES

Table 1. Tree Species Planting Zones. The Table lists the zone numbers, locations (W = west lobe of landfill, E = east lobe), the approximate area of the zones, and the general class of tree (C = conifer, HW = hardwood). Tree species are listed in Section 5.1.1.

Zone			**Tree Stand**	
Number	***Lobe of Landfill***	***Approx. Area (acres)***	***Class***	***Species***
1	W	2.6	C	Mix of pond pine and loblolly pine
2	W	2.0	C	Loblolly pine
3	W	2.2	C	Mix of eastern redcedar, Virginia pine and loblolly pine
4	W	1.6	C	Loblolly pine
5	W	1.9	HW	Mix of hardwood species, primarily Chinese elm and hackberry
6	W	2.1	C	Mix of pond pine and loblolly pine
7	W	2.2	C	Mix of pond pine and loblolly pine
8	W	2.2	C	Loblolly pine
9	W	1.9	C	Loblolly pine
10	W	2.4	HW	Hackberry and a mix of other hardwoods
11a	W	1.1	C	Mix of eastern redcedar and loblolly pine
11b	E	0.6	C	Mix of eastern redcedar and loblolly pine
12	E	1.8	C	Japanese black pine and some loblolly pine
13	E	2.0	HW	Kentucky coffee tree and a mix of the other hardwoods
14	E	1.7	C	Japanese black pine and some loblolly pine
15	E	1.7	C	Loblolly pine

Table 2. Irrigation Zone Areas and Flow Rates. Zones 11a and 11b are operated by separate valves (valves 11 and 12) that are activated at the same time.

Zone Number	Valve Number	Measured flow rate (gpm)	Drip Line Installed			Irrigation rate per acre (gpm)	Calc. acres
			Emitter spacing (ft)	Emitter rate (gph)	Emitters per acre		
1	1	54	1.50	0.42	2940	20.58	2.62
2	2	52	1.17	0.42	3769	26.38	1.97
3	3	57	1.17	0.42	3769	26.38	2.16
4	4	40	1.17	0.42	3769	26.38	1.60
5	5	58	1.50	0.61	2940	29.89	1.90
6	6	56	1.17	0.42	3769	26.38	2.12
7	7	57	1.17	0.42	3769	26.38	2.16
8	8	59	1.17	0.42	3769	26.38	2.24
9	9	50	1.17	0.42	3769	26.38	1.89
10	10	55	1.33	0.42	3316	23.21	2.37
11a	11	28	1.17	0.42	3769	26.38	1.06
11b	12	16	1.17	0.42	3769	26.38	0.61
12	13	53	1.50	0.61	2940	29.89	1.77
13	14	53	1.17	0.42	3769	26.38	2.01
14	15	45	1.17	0.42	3769	26.38	1.70
15	16	46	1.17	0.42	3769	26.38	1.66
Total							29.74

Table 3. Irrigation monitoring and control system: Parameter and instrumentation. The Table lists the parameters, the measurement units, the monitoring frequency, and the instrument locations, numbers, and types (general class of instrument and specific type). The Decagon 10HS probe is depicted in Figure 2.

Parameter		Irrigation Rate	Precip. Rate	ET Rate	Soil Moisture Content		
Units		gal/day	inches/day	inches/day	(% volumetric SM)		
Monitoring Freq.		Daily	Daily	Weekly	Daily		
Instrumentation	General Class	Flow Meter	Rain Sensor	Weather Station	Moisture Sensors		
	Location	Pump Station	On-Site	On-Site	Each Zone		
	Number	One	One	One	12 inches bgs	30 inches bgs	48 inches bgs
	Specific Type	Netafim	Campbells Scientific	Campbells Scientific	10HS or 5TE, Decagon	10HS, Decagon	Water Mark, Irrometer

Table 4. Phytoremediation System Project Schedule and Progress Reporting

Task	*Due Date*
Submit Phytoremediation Preconstruction Report to NCDWM	October 25, 2010
NCDWM approval of Preconstruction Report	TBD (not specified in RASA)
Begin construction of remaining components of phytoremediation system (i.e. installation of irrigation monitoring and control system)	Within 120 days of NCDWM approval of the Phytoremediation Preconstruction Report, and after notification to NCDWM no less than 10 days prior to commencement of major field activities.
Quarterly remedial activity construction reports to NCDWM	First report to be incorporated into the quarterly progress reports for the physical treatment system and quarterly thereafter until construction completion and system startup.
Complete construction and operational testing of phytoremediation system	As soon as practicable after NCDWM approval of Preconstruction Report
Conduct certification of completion inspection with NCDWM	Within 90 days after the Responsible Parties conclude that the phytoremediation system is constructed and operational.
Submit Construction Completion Report to NCDWM	After NCDWM inspection and agreement that construction work has been fully performed
NCDWM approval of construction completion	After NCDWM review of Construction Completion Report and determination of satisfactory completion.
Commence phased operation of phytoremediation system	As soon as practicable after completion of construction by NCDWM.
Implement Performance Monitoring and Effectiveness Evaluation Plan	Within 90 days of commencement of operation of phytoremediation system.

Table 5. Maintenance Schedule for the Phytoremediation System. See Section 9.

Task	*PRC Reference (Section)*	*Interval*
Filter inspection & maintenance	4.2.3	Monthly
Check irrigation flow rates	4.2.3	Weekly
Irrigation drip-line repair	4.2.3	As needed
Flush/fill fertigation tank	4.2.3	As Needed
Check fertigation meter; check tank levels	4.2.3	Weekly May through July
Estimate ET/transpiration; Set Master Controller	5.2	March, June, September, December
Inspect components of irrigation monitoring & control system	5.2	Monthly
Visual inspection to tree stands	7.1.1	Monthly
Plant tissue sampling	7.1.2	See Text
Soil sampling/analysis	7.1.3	See Text
Weed control	7.2.1	As Recommended
Herbicide application	7.2.1	As recommended
Fence inspection and repair	7.2.1	Monthly
Tree replacement	7.2.2	As Needed
Fertigation program operation	7.2.3	As Recommended
Monitor surface runoff from landfill cover soils	8.0	Monthly

FIGURES

Figures for Pre-Construction Report, Main Section

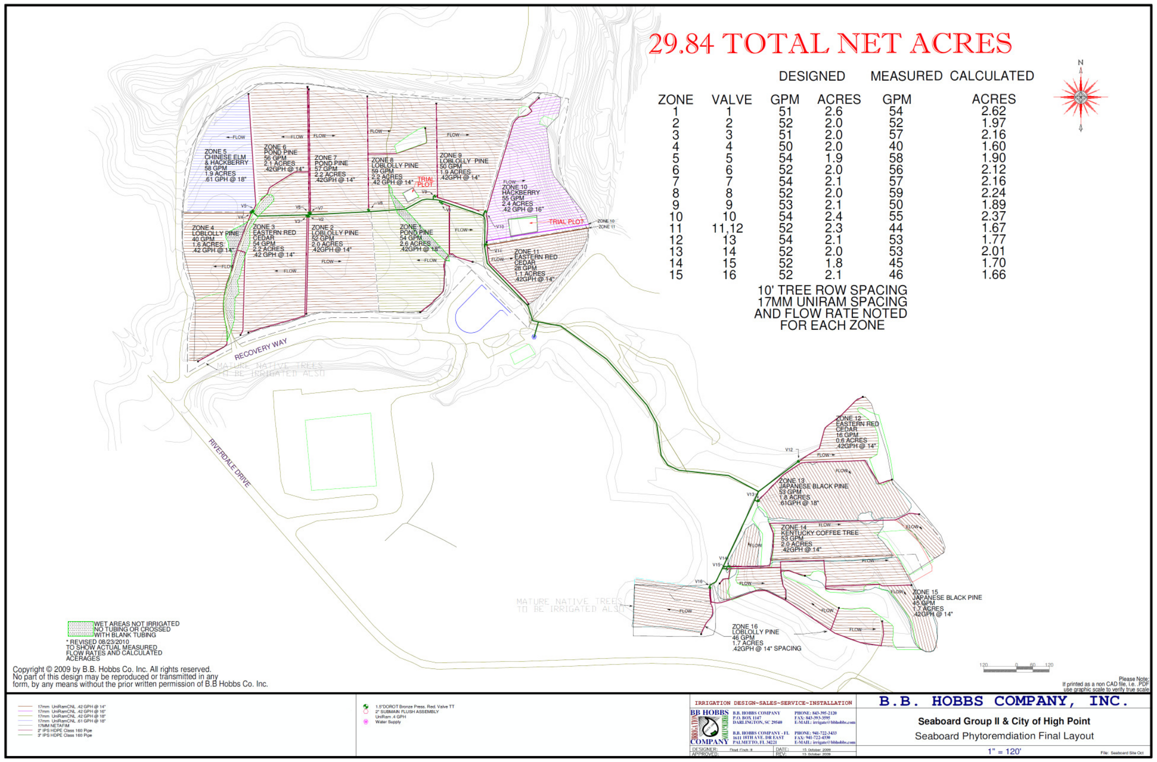


Figure 1. Plan view of the phytoremediation system. Figure depicts the west and east lobes of the Landfill and the 15-zone irrigation system.

Figure 2. Decagon 10HS Soil Moisture Sensor. See Box 1, below.

Box 1. Decagon 10HS Soil Moisture Sensor. The sensor measures the volumetric water content of the soil using a capacitance technique. The following section discusses installation procedures for the probe.

When selecting a site for installation, it is important to remember that the soil adjacent to the sensor surface has the strongest influence on the sensor reading and that the sensor measures the volumetric water content of the soil. Therefore any air gaps or excessive soil compaction around the sensor and in between the sensor prongs can profoundly influence the readings. Also, do not install the sensors adjacent to large metal objects such as metal poles or stakes. This can attenuate the sensor's electromagnetic field and adversely affect readings. In addition, the 10HS sensor should not be installed within 5 cm of the soil surface, or the sensing volume of the electromagnetic field can extend out of the soil and reduce accuracy. Because the 10HS has gaps between its prongs, it is also important to consider the particle size of the medium you are inserting the sensor into. It is possible to get sticks, bark, roots or other material stuck between the sensor prongs, which will adversely affect readings. Finally, be careful when inserting the sensors into dense soil, as the prongs can break if excessive sideways force is used when pushing them in.

Procedure

When installing the 10HS it is imperative to maximize contact between the sensor and soil. For most accurate results, the sensor should be inserted into undisturbed soil. There are two basic methods to accomplish a high quality installation.

Method 1. Horizontal Installation: Excavate a hole or trench a few centimeters deeper than the depth at which the sensor is to be installed. At the installation depth, shave off some soil from the vertical soil face exposing undisturbed soil. Insert the sensor into the undisturbed soil face until the entire sensing portion of the 10HS is inserted. The tip of each prong has been sharpened to make it easier to push the sensor in – be careful with the sharp tips! Backfill the trench taking care to pack the soil back to natural bulk density around the black plastic portion of the 10HS.

Method 2. Vertical Installation: Auger a 4 inch hole to the depth at which the sensor is to be installed. Insert the sensor into the undisturbed soil at the bottom of the auger hole using your hand or any other implement that will guide the sensor into the soil at the bottom of the hole. Many people have used a simple piece of PVC pipe with a notch cut in the end for the sensor to sit in, with the sensor cable routed inside the pipe. After inserting the sensor, remove the installation device and backfill the hole taking care to pack the soil back to natural bulk density while not damaging the black plastic portion of the sensor or the sensor cable in the process.

With either of these methods, the sensor may still be difficult to insert into extremely compact or dry soil. **Never pound the sensor into the soil!** If you have difficulty inserting the sensor, you may need to wet the soil. This will obviously result in inaccurate VWC measurements until the water added during installation redistributes into the surrounding soil.

Orientation

The sensor can be oriented in any direction. However, orienting the flat side perpendicular to the surface of the soil will minimize effects on downward water movement. Keep in mind that the sensor measures the average VWC along its length, so a vertical installation will integrate VWC over a 10 cm depth while a horizontal orientation will measure VWC at a more discrete depth.

Removing the Sensor

When removing the sensor from the soil, do not pull it out of the soil by the cable! Doing so may break internal connections and make the sensor unusable.

Appendix A
Pilot-Scale Phytoremediation Study

A1.0 Summary

A pilot-scale phytoremediation study was conducted on the west lobe of the City of High Point Landfill to test the feasibility of the 30 acre phytoremediation system. The study consisted of small plots of trees that were drip-irrigated with groundwater obtained from recovery well PW-DR1 containing 2 to 3 mg/L 1,4-dioxane. The principal objective of the pilot study was to assess the efficacy of the phytovolatilization treatment mechanism. A secondary objective was to assess the tendency of the inorganic components in the irrigation water to accumulate in the root-zone soil or the plant tissue. The pilot study was conducted in two approximately 5 week study periods during the summer of 2010, and data were obtained for five different plots. Tree species including loblolly pine, Japanese black pine, Virginia pine, willow oak, Chinese elm, and hybrid poplar were included in the study. All of the species were very effective at 1,4-dioxane uptake. The study suggested that within the limits of sensitivity for the study methods used, on average, greater than 80% of the 1,4-dioxane added to the tree plots was removed by phytovolatilization, biodegradation in the soil, or volatilization from the soil surface. Although the groundwater was moderately saline, the accumulation of salts in the root-zone of the trees appeared to be minimal due in part to their tendency to leach into deeper soil layers. The trees remained healthy during the period of irrigation, although certain inorganic compounds from the groundwater such as manganese accumulated in the plant tissue. However, these substances will be removed in a groundwater pre-treatment process for the trees in the full-scale 30-acre phytoremediation system.

A2.0 Introduction

The objective of the 30-acre phytoremediation system established on the City of High Point Landfill is to phytovolatilize the mass of 1,4-dioxane routed to the system via the irrigation water (effluent from the treatment wetland). Phytovolatilization, the treatment mechanism, involves the uptake of dioxane from the soil by the trees, translocation of the compound via the sap to the shoots, and the exit of the compound from the leaves via the transpiration gas. To test the feasibility of the phytoremediation system, a pilot-scale phytoremediation study was started in 2004 that involved the establishment on the landfill of small stands of trees of various species that were drip-irrigated with recovered groundwater. The principal objective was to assess the efficacy of the phytovolatilization treatment mechanism in the field.

The pilot study design was based in part on the results from a preliminary greenhouse study that evaluated a variety of tree species for the ability to take up 1,4-dioxane. A detailed description of the greenhouse study is available in Ferro and Tammi, 2009, reference 3. Tree species identified in the greenhouse study that could take up 1,4-dioxane where used in the pilot project. Uptake was measured by calculating the transpiration stream concentration factor: TSCF = chemical concentration in the xylem sap/chemical concentration in the soil solution. Aitchison et al. (1) had previously reported that the TSCF for 1,4-dioxane was 0.7 in hybrid poplars, that the compound was readily phytovolatilized, and that very low levels of accumulation or metabolism occurred. A TSCF of 1.0 indicates unrestricted passive uptake, meaning that the plant takes up water and the compound at the same rate.

In the greenhouse study, potted saplings of various tree species, including conifers, were irrigated with either tap water or Seaboard groundwater. The groundwater was spiked with 1,4-dioxane (75 mg/L). This concentration of 1,4-dioxane was found not to be phytotoxic to the saplings. The results of the greenhouse plant uptake study were the following (TSCF values in parentheses): Kentucky coffee tree (0.88), sycamore (0.85), hybrid poplar (DN-34; 0.68), hybrid poplar (OP-367; 0.66), white willow (0.58), loblolly pine (0.76), western redcedar (0.70), slash pine (0.60), Japanese black pine (0.44), eastern redcedar (0.4), longleaf pine (0.35).

The Seaboard groundwater is moderately saline (electrical conductivity of approximately 1,700 µmhos/cm, due to chloride and bicarbonate salts of calcium, magnesium, and sodium) and contains concentrations of manganese (7 to 8 mg/L) that can cause chlorophyll deficiency in the leaves of sensitive species (chlorosis). During irrigation of tree stands with recovered groundwater, the water would be taken up and transpired and the salts would tend accumulate in the root-zone soil. Therefore, a secondary objective of the pilot study was to assess the tendency of the inorganic components of the irrigation water to accumulate in the root-zone of the trees and in the plant tissue.

Judging from the general viability of treated and control trees in the greenhouse study, all of the conifers tested and certain hardwood species were tolerant of the Seaboard groundwater. Conifers included loblolly pine, slash pine, Japanese black pine, longleaf pine, eastern redcedar, and western redcedar. Tolerant hardwood species included hackberry, Kentucky coffee tree, Russian mulberry, and Chinese elm. Some of the hardwood species were intolerant of the groundwater and developed chlorosis, as measured using a chlorometer. These symptoms presumably were related to manganese inhibition of iron uptake (3). Hybrid poplar, alder, sycamore and black locust developed chlorosis when irrigated with the groundwater, but the addition of chelated iron prevented the symptoms.

Modeling studies using MINTEQ and SOWATCH were carried out to assess the tendency of salts to accumulate in the soil (3). The models predicted the following: a) Bicarbonate would out-gas when the irrigation water equilibrated with the soil atmosphere, limiting the steady state soil bicarbonate concentration to 25 µM; b) Manganese would precipitate as amorphous Mn carbonate, limiting its concentration to the µmolar range; and c) The salts remaining in the root-zone soil would be leachable.

A3.0 Methods, Equipment and Materials

A3.1 Pilot-Scale Phytoremediation Systems and Study Plots

Two separate pilot-scale phytoremediation systems were established on the western lobe of the City of High Point Landfill: 1) the "2004 Pilot" system contained plots with hybrid poplar and Japanese black pine; and 2) the "Plant Suitability Demonstration" (PSD) system, started in April 2006, contained a conifer plot and a hardwood plot. Both pilot systems were drip-irrigated with groundwater from recovery well PW-DR1 containing 2 to 3 mg/L 1,4-dioxane. The PSD and the 2004 Pilot plots were located in Irrigation Zones 10 and 8 of the 30 acre system, respectively (Figure 1). An estimate for the maximum value for field soil moisture capacity in these areas of the landfill is approximately 33% by volume (i.e., the design "set points", see Appendix B, Figure B2).

A3.1.1 Study Plots in the 2004 System. The system was divided into four plots (Diagram A1). Hybrid poplars were established on Plots A and B; Japanese black pine were established on Plot C. Plot D was the experimental control in which the original landfill vegetation (primarily *Lespedeza*) was maintained. Drip-irrigation rates for Plots A to C are listed in Diagram A1 (Plot D was not irrigated).

A3.1.2 Study Plots in the PSD System. The PSD pilot system had a conifer plot with seven trees and a hardwood plot with four trees (Diagram A2). Species include Chinese elm (*Ulmus parvifolia*), willow oak (*Quercus phellos*), loblolly pine (*Pinus taeda*), Virginia pine (*Pinus virginiana*), and western redcedar (*Thuja plicata*). The PSD was divided into two irrigation zones: Zone I contained the conifers; Zone II contained the hardwoods. Irrigation rates are listed in Diagram A2.

A3.2 Groundwater Irrigation and Amendments

From June 3, 2010 through the end of the 2010 growing season, the pilot plots were irrigated on a regular basis with groundwater from recovery well PW-DR1. The plots were also irrigated at regular intervals in the first half of May, but irrigation was then interrupted until June 3. The pilot plots were irrigated with untreated groundwater containing a full complement of metals as well as cVOCs (2 to 3 mg/L 1,4-dioxane and 18 mg/L cVOCs). In contrast, the full-scale system will be irrigated with groundwater plus landfill leachate that is routed through the metals removal system component of the PTS as well as through the constructed treatment wetland (Section 2.1).

A3.2.1 Iron Addition to Irrigation Water. During periods when the plots were irrigated with groundwater, chelated iron (0.086 mg Fe/L irrigation water) was added to the irrigation water to prevent chlorosis (Section A2). Stock solutions of a chelated iron product (0.82 mg/L Sequestrene 138, 6% iron derived from ferric ethylenediamine di-(o-hydroxyphenylacetate)) were diluted 575-fold using a Dosatron water-driven proportional injector. The dilution was injected into the irrigation water that was routed to the plots.

A3.2.2 Bromide Tracer Addition to Irrigation Water. Bromide tracer was added to the irrigation water to help quantify the rate at which dissolved constituents in the irrigation water drained below the root zone of the trees (i.e., for mass accounting purposes). The bromide tracer is not volatile, cannot be biodegraded in the soil, and is not readily taken up by the vegetation. However, having a negative charge and high solubility, the tracer can be readily leached. Similarly, dioxane is highly soluble and readily leached, but in contrast to the bromide tracer, it is volatile, biodegradable in soil (5), and is phytovolatilized. Thus, the loss of 1,4-dioxane mass in the pilot-scale systems could be due to a number of fate mechanisms in addition to drainage below the root zone. In contrast, the primary mechanism leading to the loss of bromide tracer mass in such systems would likely be drainage.

Potassium bromide was added to the irrigation water for the pilot plots from June 4 through August 16. The Dosatron injector was used to add a stock solution of KBr (22.49 g/L) to the irrigation water. The final concentration of KBr in the irrigation water was 39 mg/L (26.2 mg Br/L).

A3.3 Instrumentation and Equipment

Water input to the plots was measured by water flow meters installed on the supply lines for the drip-irrigation systems, and an on-site rain-bucket measured precipitation. Netafim drip lines (0.5 gph drip-emitters spaced on 1 ft centers) were used to create networks of drip-emitters in the plots. Standard irrigation system timers were installed for the tree plots and the irrigation schedules could be interrupted based on pre-set soil moisture cut-off levels (AquaPro sensors or Irrometer WEMs). Details of the instrumentation for the pilot plots are presented in Diagrams A1 and A2.

Transpiration rates for individual trees were measured using thermal dissipation probes (TDPs; Dynamax). Gee passive capillary lysimeters (Decagon) were installed in the 2004 Pilot and both bucket lysimeters and suction lysimeters (SoilMoisture Equipment) were installed in the PSD. Soil moisture sensors, and several salinity sensors, were installed at various depths in each of the plots (Diagrams 1 and 2). Data loggers for both plots stored data from all of the electronic equipment and sensors, and a modem system was used to remotely access the data.

A3.4 Sampling and Analytical Methods

During the period from June 4 through August 16, the plots were irrigated with water containing both 1,4-dioxane and bromide. The first sampling event, conducted on June 3, occurred the day prior to the start of bromide additions, and so the results from that event served as a baseline for the bromide experiment. Additional sampling events were completed on July 9 and August 16. As a result, the recovery of dioxane and bromide could be tracked for two study periods: June 4 through July 9 was the first period and July 10 through August 16 was the second. Samples were taken of soils, irrigation and drainage water, and plant tissue (woody stems as well as leaves and needles) at each sampling event.

A3.4.1 Soils analysis. Soil samples (0 to 20 inch bgs) were analyzed for HCO_3, pH, EC, Br, Ca, Cl, Fe, Mg, Mn, Na and 1,4-dioxane. 2004 Pilot: Composite samples were prepared from two core samples from each of the plots: Plots A, B, C and D. PSD: Samples were taken from the base of a Virginia pine, loblolly pine (separate samples from 2 different trees), willow oak, and Chinese elm (5 samples total).

A3.4.2 Water analysis. At each sampling event, irrigation water was sampled from the spigot near the 2004 pilot plot that had been routed from groundwater recovery well PW-DR1. The water samples were taken upstream of the proportional injector system and therefore did not contain chelated iron or bromide tracer. Samples of drainage water were taken from drain gauges in the 2004 pilot (gauges A1, B1, C2, and D2). Samples were also taken from the suction lysimeters in the PSD (0.5 ft and 3 ft bgs). Samples were analyzed for HCO_3, pH, EC, Br, Ca, Cl, Fe, Mg, Mn, Na and 1,4-dioxane.

A3.4.3 Inorganic compounds in plant tissue. Samples of leaves and needles were taken at each sampling event and analyzed for Br, Ca, Cl, Fe, Mg, Mn, and Na. The following samples were collected: 2004 Pilot 2 poplars in Plot A and 2 Japanese black pines in Plot C were sampled; PSD 2 loblolly pines, 1 Virginia pine, 1 willow oak and 1 Chinese elm were sampled.

A3.4.4 Analysis of 1,4-dioxane in plant tissue. Duplicate sections of woody tissue (approximately 2-inch long green twigs, 0.3 inch in diameter) were cut from sunlit branches of well-irrigated trees during the early afternoon. The severed ends of each branch were wrapped in parafilm. Branch samples were placed in sample bottles and shipped to the analytical lab on ice. The following samples were collected: 2004 Pilot (2 poplars in Plot A and 2 Japanese black pines in Plot C were sampled); PSD (2 loblolly pine, 1 Virginia pine, 1 willow oak, and 1 Chinese elm were sampled).

Analyses of 1,4 dioxane was performed using azeotropic distillation (EPA Method 5031), a procedure for the separation and concentration of dissolved 1,4-dioxane from solid matrices. Analysis of the distillate was done by direct aqueous injection into a Gas Chromatograph/Mass Spectrometer (EPA Method 8260B). A deuterated version of 1,4-dioxane was added to the sample prior to distillation to account for any variations in the analysis or distillation.

The percent moisture in the plant tissue was determined by weighing a portion of the sample and drying overnight at 105°C. The percent moisture was calculated by the loss in weight of the sample after drying. Based on these data, the µg dioxane/L sap was calculated. The assumption was made that all of the moisture in the plant tissue was xylem sap.

A3.4.5. Dioxane and Bromide Mass Accounting. There were five pilot plots for which mass accounting data were obtained (Diagrams A1 and A2): Three plots were in the 2004 Pilot system (poplar Plots A and B and Japanese black pine Plot C) and two plots in the PSD system (the conifer plot and hardwood plot).

Analytes added to plots. The concentration of the 1,4-dioxane in the irrigation water was measured at all three sampling events (Table A1). The volume of irrigation water added to each plot was assessed from water flow meter readings. The mass of dioxane added to the pilot plots was calculated from these data (Table A2). Similar calculations were performed for the bromide tracer added to the irrigation water using the Dosatron (Table A2).

Analytes in soil. The concentration of dioxane, bromide and other inorganic constituents were determined for the soil samples (Tables A3 through A5). The mass of soil in the 0 to 20 inch soil cores was calculated assuming a bulk density of 41 kg per ft^3 of soil. The area of soil beneath each tree was approximately 36 ft^2. The mass of dioxane recovered in the top 20 inches of the soil profile was calculated from these data (Table A6). Similar calculations were performed for the bromide tracer (Table A6).

Analytes in drainage water. The concentrations of 1,4-dioxane and bromide were measured in water samples collected from the drain gauges and suction lysimeters (Tables A7 through A9). Estimates of drainage volume were obtained in Plots A and B from the Gee passive capillary lysimeter data. The total mass of dioxane and bromide that drained below the root zone of the trees was estimated from these data (Table A10).

1,4-Dioxane in plant tissue. The concentration of 1,4-dioxane in stem tissue was measured, and the concentration of dioxane in the xylem sap was calculated based on the tissue moisture content (Tables A11 through A13). The concentration of dioxane in the soil pore water was estimated from data for the dioxane concentration in the soil (µg/kg) and soil moisture (Tables A3 to A5 and A14).

A4.0 Results and Discussion

A4.1 Water Balance

Monthly averages for transpiration for loblolly pine in the PSD are depicted in Figure A1 (average TDP data from 2 to 4 different trees, depending on the month). Transpiration rates for loblolly pine were proportional to evapotranspiration (ET), and this relationship was also observed for the other tree species. Therefore, ET values were used to predict the changing rates of transpiration for the tree stands throughout the season. However, for a given ET value, the transpiration rates were different for the various species (Table A15), and these differences were taken into account in deciding the irrigation rate necessary to maintain a water balance for the plot.

By manipulating the irrigation schedule for each plot, the cumulative liters of water entering a plot during a specific time period (precipitation plus irrigation) was roughly balanced against the liters exiting the plot via transpiration. During the 2010 growing season, the pilot stands had nearly closed canopies and the understory vegetation was mowed. Therefore, transpiration by the trees probably was the main mechanism for water exiting the plots. Data for water input into the plots (irrigation plus precipitation) and average cumulative transpiration are presented in Table A6.

Depending on how closely the water balance was maintained, the average soil moisture in the plots either increased or decreased. Average daily volumetric soil moisture in each of the five plots is depicted in Figure A2, top panel. Corresponding values for ET and precipitation are depicted in Figure A2, bottom panel. During the first study period (6/3 to 7/8), there was little precipitation. However, during the second study period there were substantial rain events that caused spikes in the soil moisture content. When soil moisture exceeded the field capacity, drainage occurred. For example, data were obtained from the Gee passive capillary lysimeters in Plots A and B for a drainage event in mid-July (Figure 3A). The drainage event was caused by a rain storm on July 13.

A4.2 1,4-Dioxane and Bromide Mass Accounting

The mass of 1,4-dioxane and bromide added to the pilot plots via the irrigation water during the first and second study periods is presented in Table A6. By the end of the first study period (6/3 to 7/8), the added bromide was recovered nearly quantitatively in the upper 20 inch portion of the soil profile. The 1,4-dioxane recovery was about 14% (average for the various plots), and the assumption was made that the leachability for bromide and dioxane were about the same. The relatively low recovery for 1,4-dioxane was probably due to plant uptake and phytovolatilization or other processes such as volatilization from the soil surface and biodegradation. Thus, about 86% of the 1,4-dioxane was removed by phytovolatilization and other processes.

By the end of the second study period (7/9 to 8/16), the percentage of bromide recovery in the soil was much lower for certain plots. For example, only 46% of the added bromide was recovered in the soils of the poplar Plots A and B, and 60% in the two PSD plots. The drainage event in mid-July evidently resulted in the leaching of the bromide added during the first study period from the upper 20 inches of the soil profile. However, the percent bromide recovery in Plot C was nearly quantitative, probably because the water balance was better maintained in this plot (Table A6).

Although the bromide recovery in the soil fraction was low for most of the plots during the second study period, the percent 1,4-dioxane recovery in the soil was much lower. The relatively low 1,4-dioxane recovery (around 4.5 % on average) was probably due to fate mechanism such as phytovolatilization and biodegradation, as well as leaching.

In Table A10, the mass of 1,4-dioxane and bromide recovered in the drainage water during the second study period was calculated for Plots A and B. The calculations were based on analyte concentrations in samples of drainage water (drain gauges A1 and B1, Table A9) and the volume of drainage estimated during the second study period (Figure A3). For Plots A and B, the average mass of bromide in the drainage water was roughly 18.4 g per tree and the estimated mass of bromide recovered in the soil was 21.4 g per tree. Thus, about 86% of the bromide was accounted for in the soil and drainage water. In contrast, only 18.4 % of the cumulative added mass of 1,4-dioxane was recovered, 0.61 g/tree recovered in the drainage water and 0.31 g/tree recovered in the soil.

A4.3 Plant Uptake of 1,4-Dioxane

The relative concentrations of the 1,4-dioxane in the xylem sap and the soil water at the time of sampling provided a rough estimate of the uptake efficiency for the various tree species. The concentrations of 1,4-dioxane in the xylem sap of samples collected on 7/8, at the end of the first study period and after several weeks of regular irrigation, were very high for all of the species (Table 14). Concentrations ranged from 1,400 µg/L sap for the conifers in the PSD to 1,800 µg/L sap for the poplars in Plot A. On this sampling event, the concentrations in the xylem sap were several-fold higher than the concentrations in the soil water.

The concentrations of 1,4-dioxane in the xylem sap from samples collected on 8/16 were significantly lower than those from 7/8. However, the relative concentrations in sap and soil water suggested good uptake efficiency. The lower concentrations in xylem sap from the 8/16 samples were probably due to the infrequent irrigation for most of the plots in the few days prior to the 8/16 sampling event (Figure A4). Frequent rains in the last few weeks of the second study period resulted in soils with high moisture contents, and the frequency of irrigation had been decreased in order to maintain the water balance.

A4.4 Soil Salinity Analysis

The pilot study was not long enough to thoroughly evaluate the potential for salt accumulation in the root-zone soils. However, preliminary results from the pilot study suggested that salt accumulation in the root-zone soils may not pose a significant problem for the 30-acre phytoremediation system. There were no significant changes in EC, Cl, bicarbonate or plant available manganese concentrations in the soil profile as a result of irrigation with contaminated groundwater during the first and second study periods. Chloride concentrations and EC may have increased to expected levels by the end of the first study period but then leveled off by the end of the second period, suggesting leachability of the accumulated salts. Bicarbonate concentrations did not change during the irrigation with water containing relatively high concentrations of bicarbonate, suggesting that the out-gassing prediction of the model was correct (Section 2.0). Plant available manganese did not increase in concentration, a result also in keeping with model predictions.

A4.5 Plant Tissue Analysis

Plant tissue samples (leaves or needles) were analyzed from samples taken on 6/4 (baseline) and at the end of the first and second study periods (Tables 16 through 18). Data are presented graphically in Figure A5 for water extractable chloride, calcium, magnesium and manganese. Striking species-specific differences were observed:

- Chloride: concentrations appeared to increase for poplar and Virginia pine, but not for Japanese black pine, loblolly pine, willow oak, and Chinese elm.
- Calcium: increases were noted for poplar and Chinese elm, and possibly for Virginia pine and oak, but not for Japanese black pine and loblolly pine.
- Magnesium: increases were observed for all of the species except Japanese black pine.
- Manganese: increases were observed for all of the species.

The pilot study was not long enough to thoroughly evaluate the potential for accumulation of inorganic constituents in plant tissue. However, these results underscore the importance of the metals removal system in the PTS for the pre-treatment of irrigation water for the 30-acre phytoremediation system (Section 2.1). For example, the accumulation of manganese in plant tissue observed in the pilot study could eventually be phytotoxic. The results also support the need to perform regular plant tissue analyses (Section 7.1.2) and possibly fertigation with chelated iron (Section 7.2.3) after irrigation with wetland effluent is started for the 30-acre system.

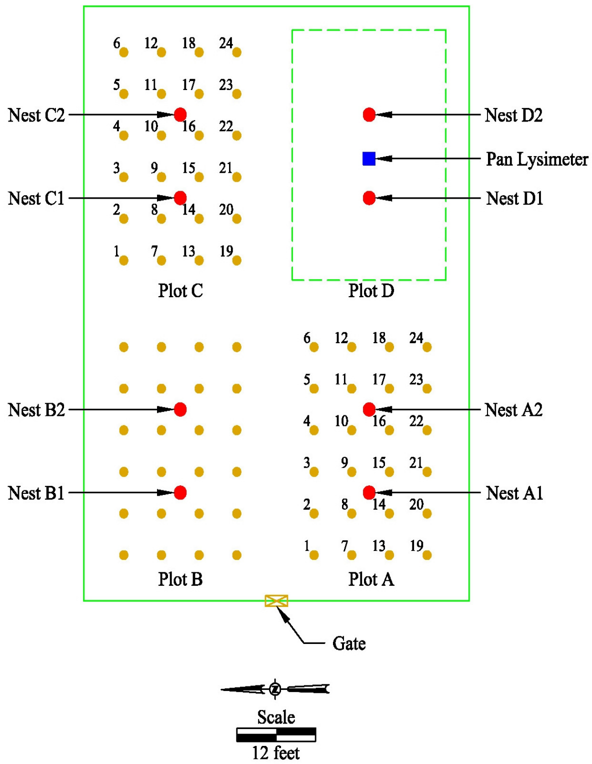
A5.0 Conclusions

The pilot studies suggested that the drip-irrigation of tree stands established on the landfill was an effective treatment process of the removal of the 1,4-dioxane dissolved in the irrigation water. During the first study period there was little precipitation and the water balance for the plots was relatively well-maintained. The bromide tracer recovery in the soil fraction was nearly quantitative indicating that leaching below the root zone was minimal. The recovery of 1,4-dioxnae in the soil fraction was only 14% by the end of the first study period, indicating that roughly 86% of the dioxane was removed by phytovolatilization by the trees and understory vegetation or evaporation from the soil surface. The conservative assumption was made that 1,4-dioxane would leach no more readily than the bromide tracer, and therefore leaching was not a fate mechanism for loss of dioxane during the first study period.

During the second study period, substantial rain storms evidently resulting in leaching of soluble analytes out of the upper 20 inches of the soil profile. At least for the poplar Plots A and B, the extent of leaching could be roughly quantified using the Gee Passive capillary lysimeters. By the end of the second study period, about 40% of the cumulative bromide tracer added to each of the poplar plots was recovered, on average, in the drainage water, and 46% of the tracer was recovered in the soil. Although 86% of the bromide tracer could be accounted for, only 18.4% of the dioxane was accounted for, either in the soil (6.2%) or in the drainage water (12.2%). Thus, during the second study period, the evidence suggested that processes such as phytovolatilization were effective for the removal of roughly 80% of the 1,4-dioxane, the heavy rainstorms and resulting leaching notwithstanding. As far as a test for the 30-acre phytoremediation system, phytovolatilization by the trees or understory vegetation, biodegradation in the soil, or volatilization from the soil surface would all be considered effective treatment mechanisms. On the other hand, leaching below the root zone of the trees would be undesirable.

The relatively high concentrations of 1,4-dioxane in the xylem sap of all of the trees after the first study period confirmed the observations made in the greenhouse study: The tendency of dioxane to be taken up by plants is a characteristic of the compound itself (e.g., its miscibility with water and relatively small molecular size) and not a characteristic that is specific to certain plants. The TSCF is the ratios of chemical concentration in the xylem sap to the chemical concentration in the soil solution that the plant is taking up. The instantaneous concentration ratios of dioxane in the sap and soil water were calculated for the two sampling events (Table A14). However, true TSCF values could not be measured in the field because the concentrations of dioxane in the soil solution would fluctuate in response to irrigation events or rain storms. Changes in concentration of dioxane in the xylem sap of the stems would mirror these changes in the soil water, but would be delayed by several days as the dioxane taken up by the roots flows via the sap to the stem tissue

Diagram A1. 2004 Pilot Plot, Layout and Instrumentation

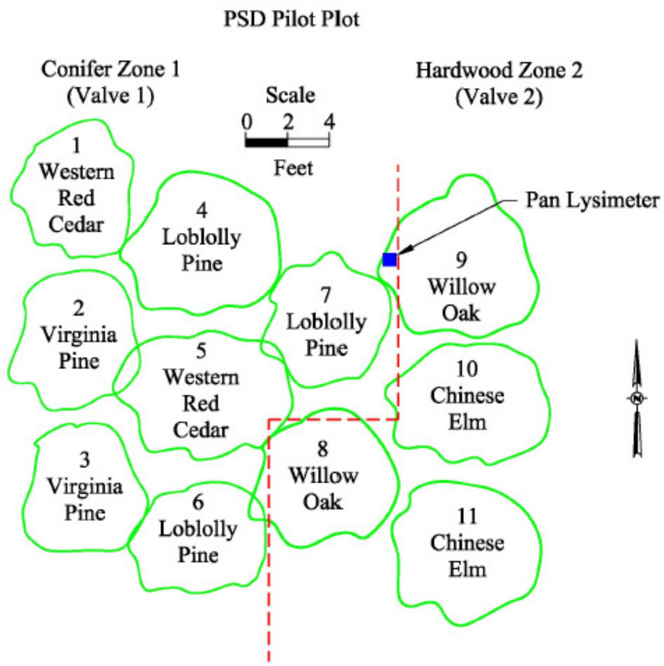


The 2004 Pilot contains four 864 ft^2 plots

- Plot A, 24 hybrid poplar (*Populus deltoides x nigra*; DN-34), irrigation rate **2.9 gpm**
- Plot B, 24 hybrid poplar, irrigation rate **2.4 gpm**
- Plot C, 21 Japanese black pine, 3 loblolly pine (trees 4-6), irrigation rate **2.6 gpm**
- Plot D, control plot, containing native landfill vegetation (*Lespedeza sericea*).

		Poplar tree plots (Plots A and B)				Japanese black pine plot		Control plot	
Sensor	Type	Nest A1	Nest A2	Nest B1	Nest B2	Nest C1	Nest C2	Nest D1	Nest D2
Soil moisture	ECH2O Decagon	2 ft bgs	1 & 3 ft bgs	1, 2 & 3 ft bgs	1, 2 & 3 ft bgs	3 ft bgs	1 & 2 ft bgs	1, 2 & 3 ft bgs	1 & 3 ft bgs
	10 HS Decagon					1.5 ft bgs			
Soil salinity/ moisture	Stevens Hydraprobe	2 ft bgs							
	5TE Decagon	1.5 ft bgs							
Drain gauges	Gee capillary lysimeter	1.5 ft bgs		1.5 ft bgs	[flooded?]	[flooded?]			1.5 ft bgs
	Pan lysimeter							1.5 ft bgs	
Irrigation control	AquaPro	1 ft bgs		1 ft bgs		1 ft bgs			
TDP	Dynamax	Trees 3 and 4				JBPs 8, 9 and 14; LP 5			

Diagram A2. PSD Pilot Plot, Layout and Instrumentation



	Irrig. Zone	Conifer Zone (Irrigation Zone 1, rate **2.5 gpm**)							Hardwood Zone (Irrigation Zone 2, rate **1.2 gpm**)			
	Tree number	1	2	3	4	5	6	7	8	9	10	11
	Tree species	WR	VP	VP	LP	WR	LP	LP	WO	W0	CE	CE
Sensor	Type											
Soil moisture	PR2/6 Delta-T										10, 30, 40, 60 cm bgs	
	10HS Decagon							1 & 2 ft bgs				
	WaterMark Irrometer							1 & 1.5 ft bgs				
Soil salinity/ moisture	Stevens Hydraprobe							2 ft bgs	2 ft bgs			
	5TE Decagon						1.5 ft bgs					
Drain gauge	Pan lysimeter							1.5 ft bgs; see Fig.		1.5 ft bgs; see Fig.		
Irrig. controller	WEM Irrometer				1, 1.5 ft bgs						1 & 1.5 ft bgs	
Suction Lysimeters*					0.5 & 3 ft bgs							
TDP	Dynamax		+	+	+		+	+	+		+	

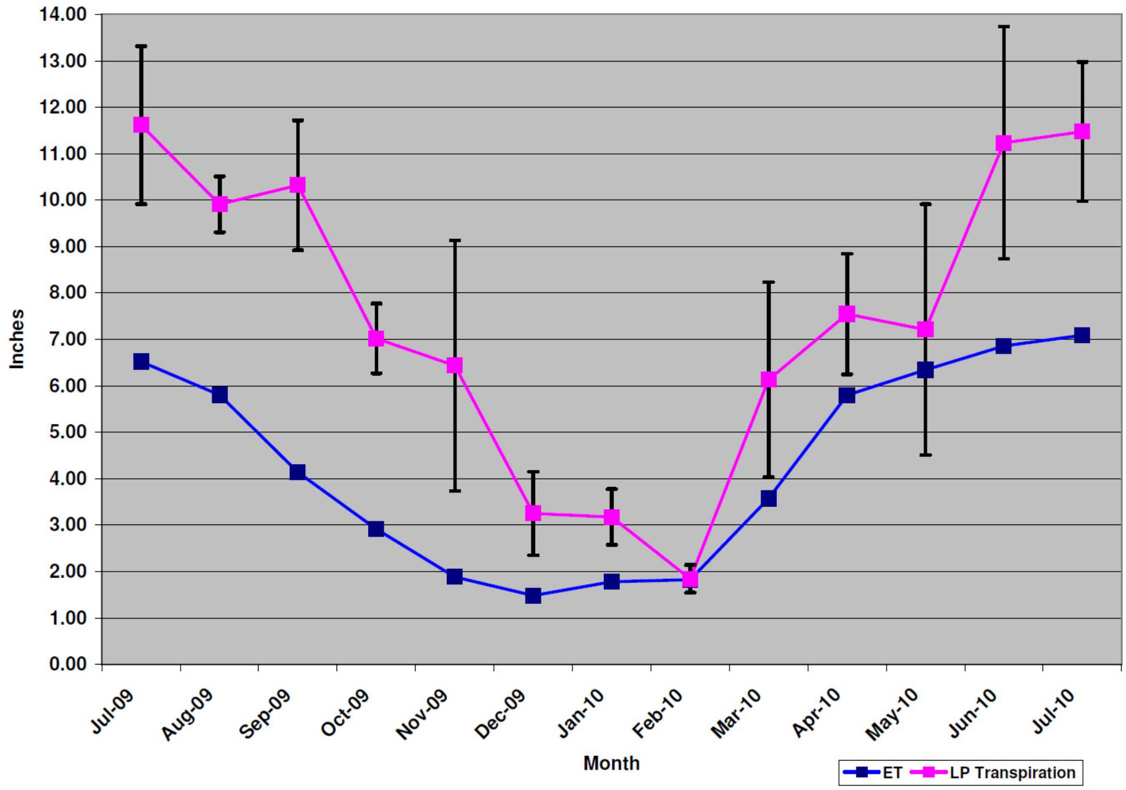


Figure A1. Monthly averages for ET and transpiration of loblolly pine in the PSD. Data for ET were obtained from the Greensboro, NC, airport. Data for transpiration were average values for from 2 to 4 TDPs installed in different loblolly pine trees.

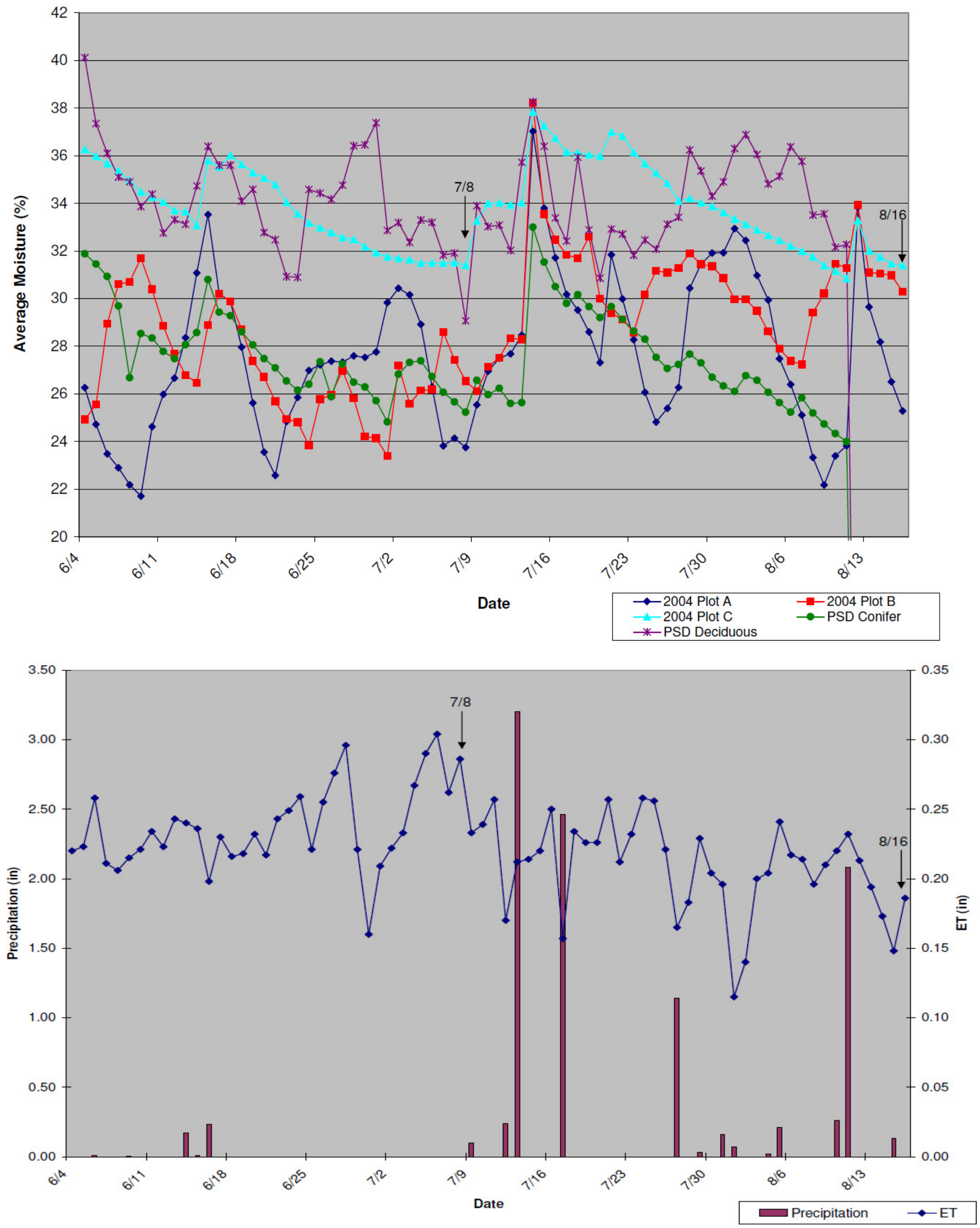


Figure A2. Water balance data for the two study periods. Top panel, data for average soil moisture for each of the five plots. Bottom panel, data for precipitation and ET. Arrows indicate sampling events at 7/8/2010 and 8/16/2010. Note that soil moisture sensors in some of the plots (e.g., Plot C in the 2004 Pilot and the PSD hardwood plot) were evidently installed in clayey layers of soil and therefore provided aberrantly high values for soil moisture.

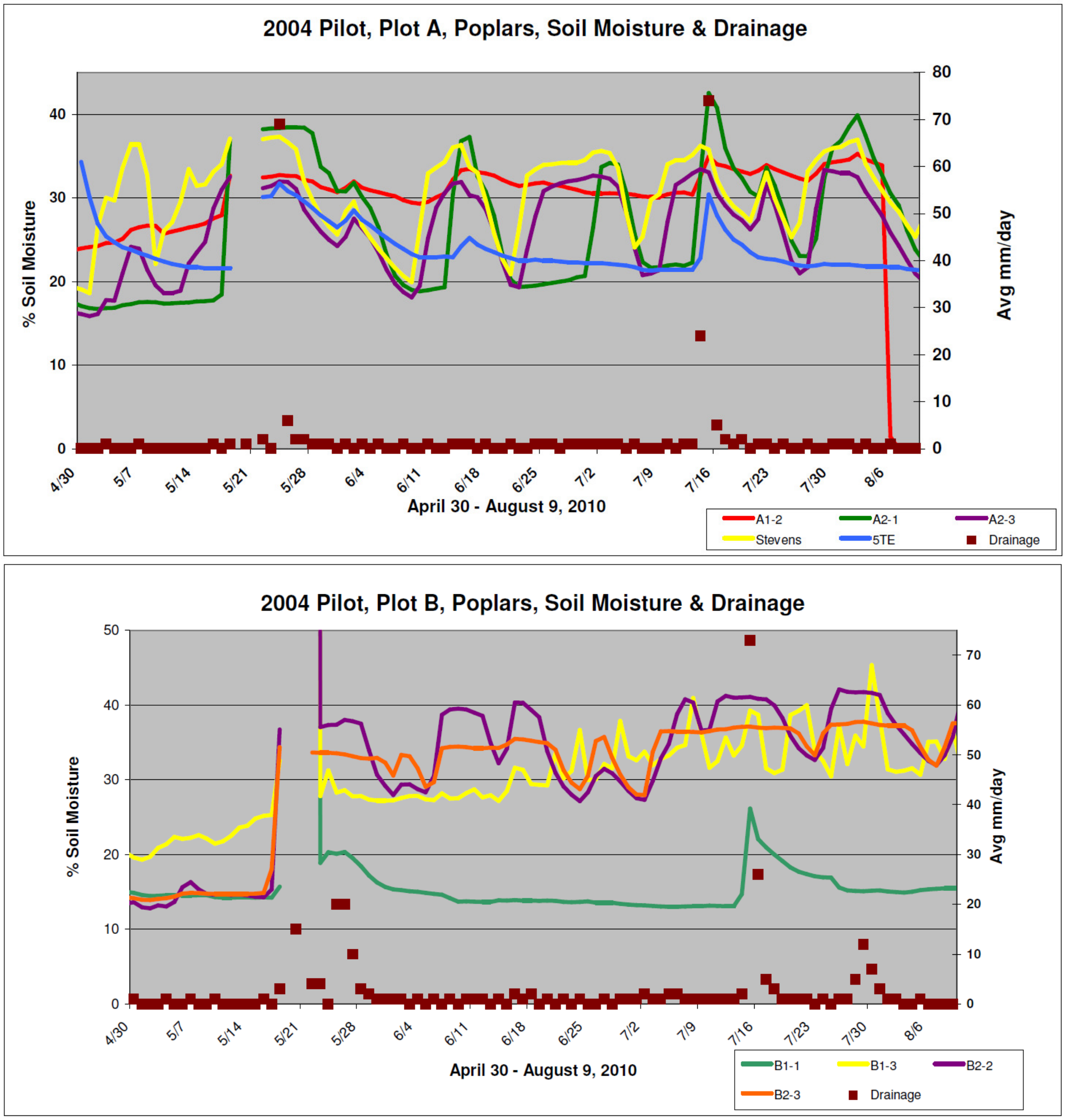


Figure A3. Drainage data for Plots A and B. Top panel, data for Plot A. Bottom panel, data for Plot B. For both plots, a drainage event was observed during the second study period in mid-July that corresponded with a large rain event on 7/13. An earlier drainage event occurred around 5/25 prior to the first study period. Data are from the Gee passive capillary lysimeters in the plots.

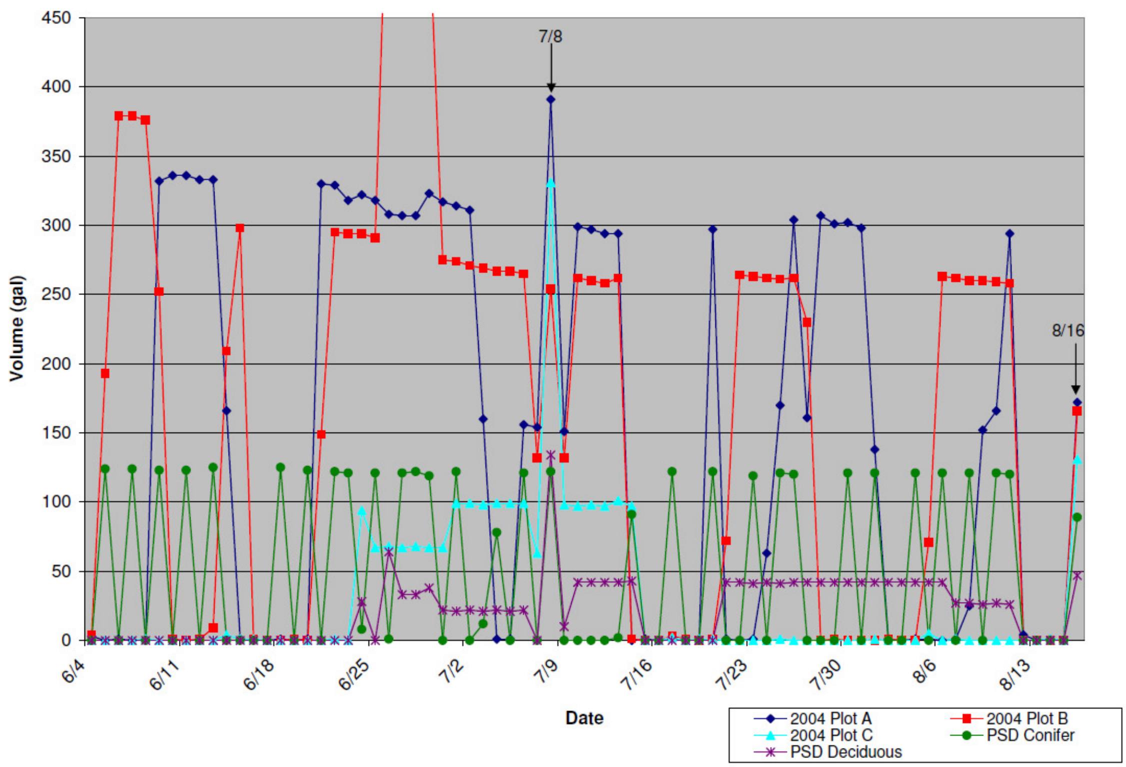


Figure A4. Irrigation schedules for the plots during the first and second study periods.

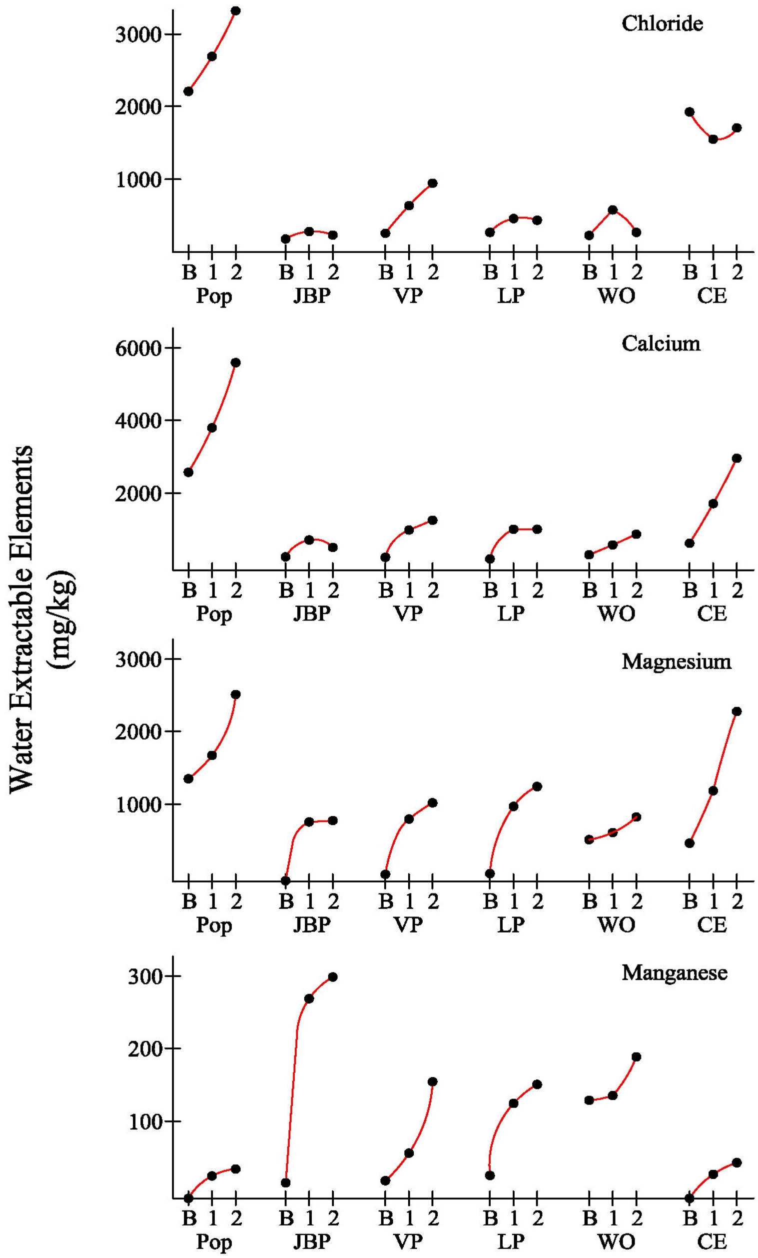


Figure A5. Concentrations of water-extractable elements in tissue samples at each of the three sampling events. Sampling times: ***B***, baseline samples 6/4; ***1***, samples taken on 7/8 after first study period; ***2***, samples taken on 8/16 after second study period. Abbreviations: Pop, poplar; JBP, Japanese black pine; VP, Virginia pine; LP, loblolly pine; WO, willow oak; CE, Chinese elm.

Appendix B

Soil Water Characteristic Curves

B1.0 Summary

Composite soil samples were obtained for each of the 15 irrigation zones in the 30 acre phytoremediation system and soil water characteristic curves (SWCCs) determined. The data suggested that the soils from the landfill have water-holding characteristics similar to typical loam or sandy loam soils. For example, at -33 kPa the average volumetric soil moisture content was 22.4%, typical of sandy loam soil. These data were used to assign “set points” for the irrigation monitoring and control system (Pre-Construction Report, Section 8). The tentative average set points for each of the irrigation zones will be equal to the volumetric soil moisture of 27.3 to 41.6%, average 33.9%. As explained in the sections below, this soil moisture content is attained at a soil suction of -4 kPa.

B2.0 Introduction and Background

A graph showing a series of soil moisture percentages versus applied tension or soil suction is called a soil water characteristic curve (SWCC). Tension or suction is measured in bars of kilopascals (0.01 bars = 1 kPa). There are a series of terms that provide generalized guidelines for soil moisture percentages that relate to plant growth. *Gravitational water* is that portion of soil water that will drain freely under gravity. Gravitational water is typically set at a potential of -33 kPa, but it is closer to -10 kPa in sandy soil. *Field capacity* is the percentage of soil moisture held with a potential less that that for gravitational water. *Permanent wilting point* is the percentage of soil moisture held with potential less than -1,500 kPa. *Water holding capacity* (WHC) is generally defined as the difference of moisture between -33 kPa and -1,500 kPa. The WHC is equivalent to *plant-available moisture*.

In addition to having an adequate water holding capacity (as indicated by the SWCC data), the landfill soil cover must have certain other characteristics in order for the phytoremediation system to be effective for treating 1,4-dioxane contaminated water. Specifically, the soils must have adequate percolation rates, nutrient content, and other agronomic characteristic to be adequate for the development of tree stands. In order to assess the feasibility of the phytoremediation system, therefore, certain other preliminary studies were performed.

Tests of percolation rates were carried out. The test system consisted of a 90 ft^2 drip-emitter system and a centralized sensor that measured soil moisture at 10, 20, 30, 40, 60 and 100 cm below ground surface (8). The system was used to test 18 test plots on the western lobe and 3 plots on the eastern lobe of the landfill. The plots were irrigated (at a rate of 2.1 inches per hour) to bring the soil profile to its full water holding capacity, and then irrigation was continued to assess infiltration rates. To obtain estimates of *in situ* “field capacity”, the irrigation was stopped and measurements of soil moisture content continued for several days. The infiltration rate at the test plots was generally at least 1 inch/hr (typical of a silt loam soil), and the field capacity was 21% to 35% volumetric soil moisture (average = 28.5%). These data were comparable to the data from the SWCCs for volumetric water content at 10 kPa soil suction (22.1-31.2 %, average = 26.1%).

Soil nutrient status was analyzed in composite soil samples from each of the 15 irrigation zones (10). Data were obtained for plant-available nutrients (P, K, S, Mg, Ca, Mn, Zn, and Cu), pH and cation exchange capacity (CEC). The soils in almost all zones were somewhat deficient in K. Certain areas were also deficient in P (4 acres) or S (9 acres). About 60% of the area of the tree stands had soil pH > 7. The optimal pH is 5.5 for conifers and 6 for hardwoods. The average CEC of the soils were moderate to high and indicated that the soils can maintain adequate reserves of nutrients. Nutrient imbalances can result from the alkaline pH of the soil in certain zones, and these imbalances can be exacerbated by nutrient deficiencies. Such imbalances probably can be addressed in future growing seasons using the fertigation system (Pre-Construction Report, Section 5.2).

The rate of tree development is clearly reduced in certain areas of the 30 acre phytoremediation system (Zones 3, 6 and 7). Analysis of plant tissue taken from these affected areas indicated abnormally high levels of aluminum, copper and iron (7). Soil nutrient status of the soils in these zones indicated pH = 7.5 and high levels of copper. The reason for inhibition of tree growth is currently under investigation, but Zone 3 is an area that was near and old burn pit, and the ash residue may have been spread in the affected area. Zone 3 also was an area where wastewater disposal formerly occurred. Certain trees species, including Virginia pine, are reportedly aluminum tolerant (6). Therefore, in spring, 2010, Virginia pine seedlings were planted in Zone 3. As of September, 2010, the Virginia pine seem to be exhibiting better performance than the loblolly pine seedlings planted in spring, 2009.

B3.0 Methods

Each irrigation zone was divided into two to five sampling areas based on relative rates of trees growth and site topography. There were 48 sampling areas, 33 on the west lobe and 15 on the east lobe (10). Soil cores (0 – 2 ft bgs) were taken in May, 2010, from each Sampling Area. The soil cores from a given irrigation zone were mixed to form 15 different composite samples, one composite from each irrigation zone. Percent gravimetric soil moisture was determined by Energy Labs (Helena, MT) at saturation as well as at 0.1, 1 and 10 bars of soil suction (0, 10, 100 and 1000 kPa).

B4.0 Results

The results are presented in Table B1. In Figure A1 (Appendix A), representative data from several zones are presented in semi-logarithmic plots, kPa soil suction (0 [saturated], 10, 100 and 1,000 kPa) vs. soil moisture (percent gravimetric). Reading the data from the semi-log plots, the values for field capacity (θ_{fc}), permanent wilting point, and plant available moisture were determined in terms of percent gravimetric soil moisture (%wt). These data were converted into percent volumetric soil moisture, assuming a soil bulk density equal to 1.3 g/cm^3 (Table B2).

Average SWCC data for the composite soil samples from the landfill were compared to literature data for typical soils (Table B2). The average moisture content of the Seaboard soil at -33 kPa (22.4% by volume) is similar to that of a typical sandy loam. The average moisture content at -1,500 kPa (10.4% volume) is typical of a loam. The WHC (Section B2) of the landfill cover soil is 1.5 inches per foot, about the same as a typical sandy loam.

The Master Controller will be programmed with preliminary design set points (Pre-Construction Report Section 5). These design set points will be percent volumetric soil moisture at -4 kPa soil suction (Figure B2). Across all zones, the average value for volumetric soil moisture at -4 kPa is 33.9%. Values of soil suction less negative than -4 kPa would probably be gravitational water, i.e., moisture that would drain freely under gravity. The design set points for the various irrigation zones ranged from 27.3 % volumetric in Zone 14 to 41.6 % in Zone 3 (Figure B2). The final working set points may be modified based on future observation. Thus, as the irrigation control system is operated and data collected, the set points may be changed to values more negative than -4kPa (e.g. closer to -10 kPa).

Table B1 Data from Energy Labs for the 15 composite soil samples. Percent gravimetric moisture (wt%) at saturation, 0.1 bar, 1.0 bar, and 10 bars of soil suction. In terms of kPa, soil suction values were 0, 10, 100 and 1,000 kPa.

	Percent Sat	0_1 Bar Moisture	1_0 Bar Moisture	10 Bar Moisture
	%	wt%	wt%	wt%
Client Sample ID	Results	Results	Results	Results
Zone 1	32.7	19	13	7.6
Zone 2	34.2	20	13	9.0
Zone 3	44.0	24	18	12
Zone 4	40.5	22	17	10
Zone 5	38.0	21	17	11
Zone 6	34.7	20	13	8.0
Zone 7	35.5	20	14	8.8
Zone 8	34.5	20	15	9.3
Zone 9	30.0	18	13	7.9
Zone 10	33.7	20	15	10
Zone 11	37.6	21	16	9.9
Zone 12	34.3	20	14	8.3
Zone 13	36.0	21	15	9.6
Zone 14	27.7	17	11	7.2
Zone 15	30.9	19	14	7.8

Table B2 Comparison of SWCC values for typical soils and average data for the Seaboard composite soils samples. Literature values were obtained for typical soils (2). The percent moisture by volume was calculated assuming a soil bulk density of 1.3 g/cc.

Soil type	Soil Suction		Soil Moisture			WHC per foot (inches)
	Bars	kPa	% by mass	% by volume	Inches per foot	
Sandy loam	-0.33	-33	15	19.5	2.3	1.9
	-15	-1,500	4	3.1	0.4	
Loam	-0.33	-33	22	28.6	3.4	2.3
	-15	-1,500	7	9.1	1.1	
Silt loam	-0.33	-33	30	39	4.7	3.1
	-15	-1,500	10	13	1.6	
Landfill cover	-0.33	-33	17.2	22.4	2.7	1.5
	-15	-1,500	8.0	10.4	1.2	

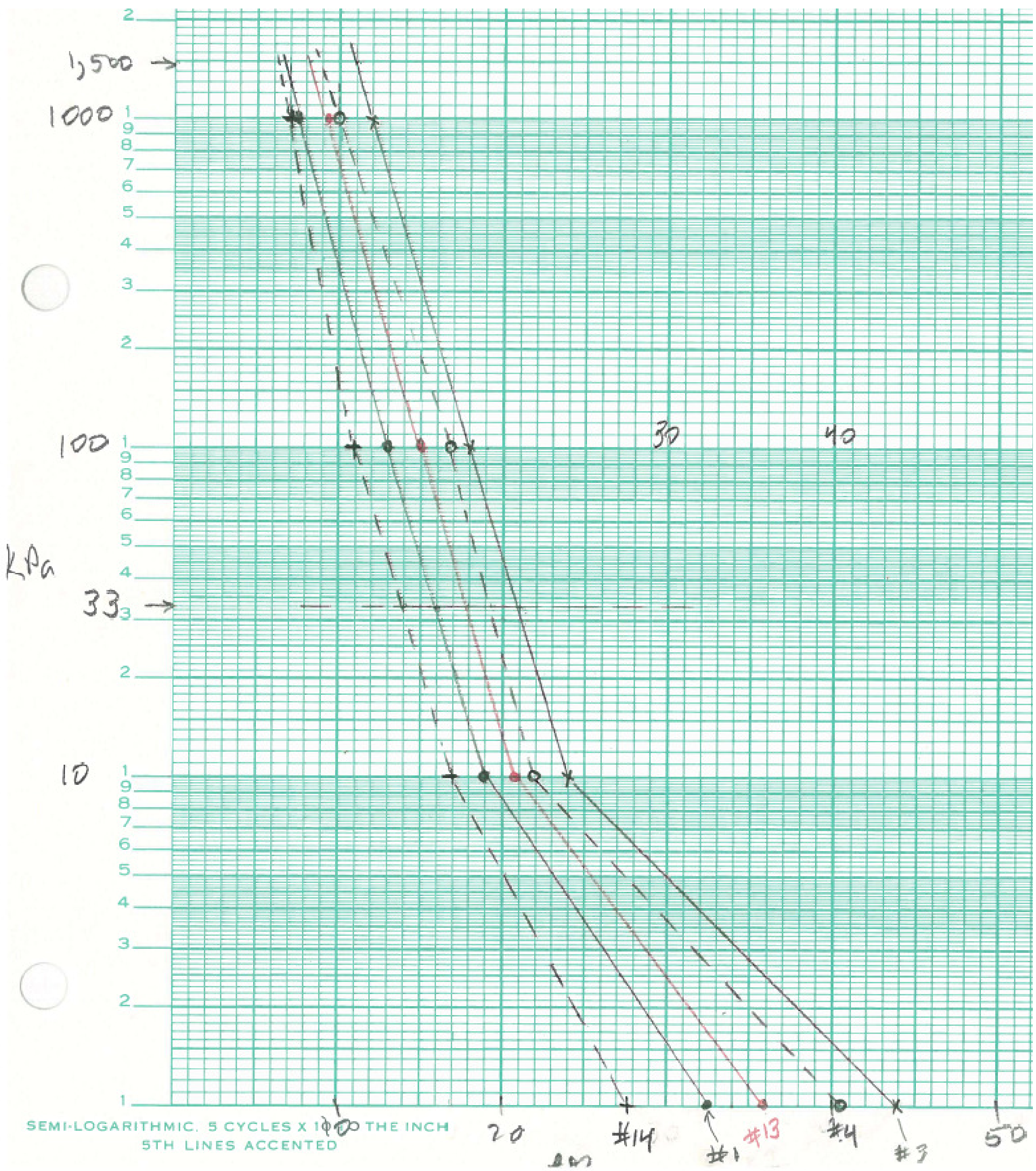


Figure B1. Representative Semi-log plots. Plots are kPa soil suction (y-axis) vs. soil moisture (wt%) for soils from Irrigation Zones 1, 3, 4, 13, and 14. Soil suction: 0 (saturated), 0.1, 1 and 10 kPa.

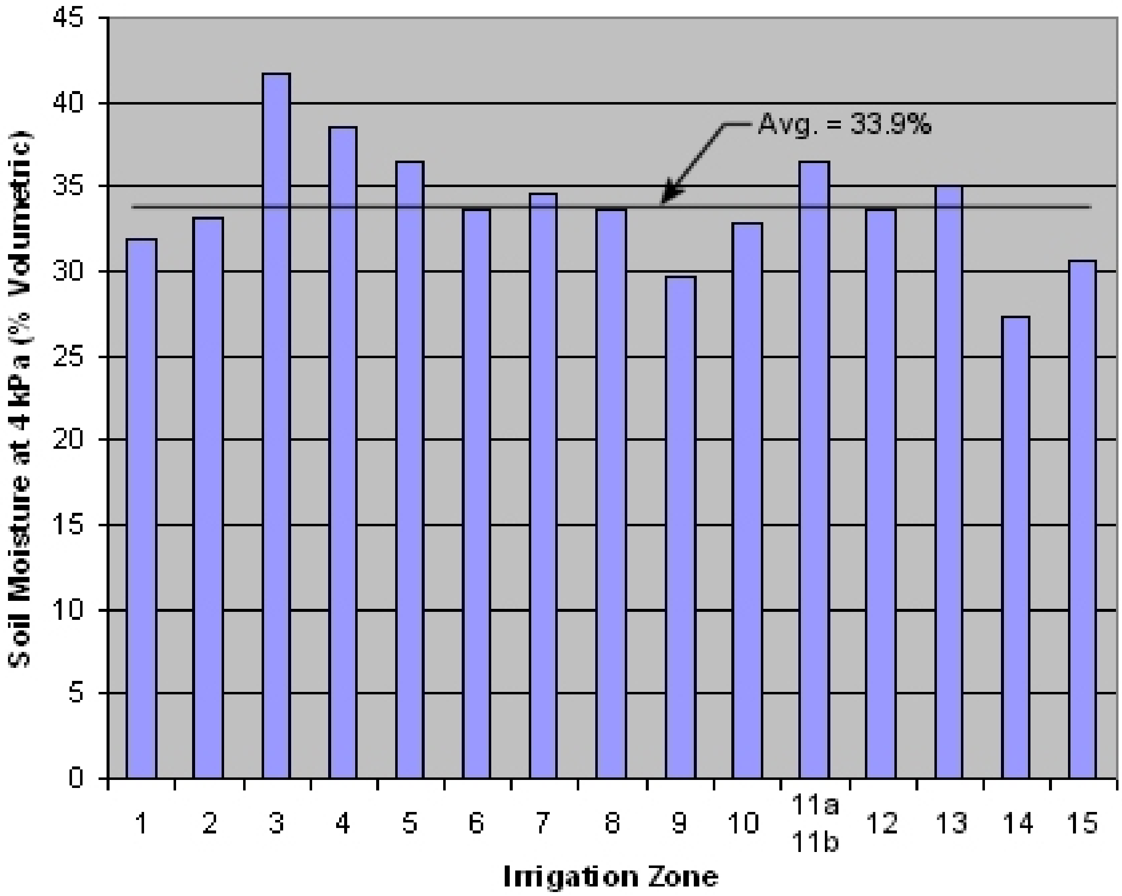


Figure B2. Design "Set Points" for the different irrigation zones. The design or preliminary set points are equal -4 kPa soil suction. Across all zones, the value for volumetric soil moisture at -4kPa is 33.9 %.

Appendix C

Water Balance for Idealized Tree Stands

The purpose of this Appendix is to estimate the volume per month of the wetland effluent that will need to be diverted to the PTS, given a best-case scenario. In this idealized case, tree stands of similar area and composition as those in the phytoremediation system are postulated to be established at an ideal site with the same climatic factors as exist at High Point.

Thus, for the idealized case, there are fifteen 2-acre stands, three containing hardwood trees and 12 containing coniferous trees. Good quality, contaminant free water (up to 50 gpm, 26.3 million gallons per year) is available for irrigation. The hardwood stands can be irrigated from mid-April through mid-October, and the 12 coniferous stands are available for year-round irrigation. A water balance is maintained for the idealized stands, and therefore water input from irrigation and precipitation is balanced against transpiration by the trees.

The idealized stands would be composed of large, mature trees with a completely closed canopy at a density of 435 trees per acre (the planting density for the trees in the 30 acre phytoremediation system). There would be no plant stress of any kind for the idealized stand. Based on literature values for energy transfer and physiological parameters, the following equation, was used to estimate the potential transpiration rate (3, 4):

$$V_T = ET * \theta * LAI, \qquad \textit{(equation 1)}$$

In equation 1, V_T is the potential transpiration rate for the stand, ET is reference transpiration, θ is the water use coefficient, and LAI is the leaf area index. Potential transpiration is the rate of water use for a stand provided with optimal soil moisture. Reference transpiration (ET) is the rate of water use for a well-watered, 6-inch tall fescue turf. The leaf area index (LAI) is the leaf area covering a unit area of ground surface, estimated to be 6 for an idealized hardwood stand and 10 for that of a conifer stand.

The water use coefficient (θ) is the rate of water use per unit leaf area as a percentage of ET. Idealized values for θ were estimated to be 0.5 for hardwood trees and 0.3 for conifers. Any type of plant stress can decrease the value for θ, including moisture deficiency, excess salinity, nutritional deficiency or imbalance, poor soil conditions (e.g., compaction), and phytotoxicity created by inorganic or organic constituents.

In Table C1, precipitation data are 30 year averages. Data for the driest year and wettest year in the past 30 years are provided in Tables C2 and C3. Monthly ET data are 15 year averages estimated from monthly pan evaporation data from the Greensboro airport (ET assumed to be approximately 80% of pan evaporation). Monthly infiltrating precipitation was estimated assuming 15% of total is intercepted and evaporates directly from the leaves. The irrigation capacity is the average inches of transpiration minus the average inches of infiltrating precipitation. In the Tables, the assumption is made that the irrigation rate is 50 gpm for every month and that a water balance is always maintained. The percent overage (i.e., the percent of the irrigation water that cannot be used by the tree stands) is shown in the last columns.

Table C1. Estimated irrigation capacity during *average year*.

Month	ET	Trans-piration estimated	Precipitation (average, infiltrating)	Irrigation Capacity	Overage (assuming fifteen zones)	
	inches	*inches*	*inches*	*inches*	*%*	*gpm*
Jan	1.4	4.3	2.8	1.5	52	26
Feb	1.8	5.3	2.6	2.7	14	7
Mar	3.2	9.6	3.1	6.5	0	
Apr	4.2	12.5	3.2	9.3	0	
May	5.1	15.4	2.9	12.5	0	
Jun	5.4	16.1	3.2	12.9	0	
Jul	5.4	16.1	3.7	12.4	0	
Aug	5.0	14.9	3.1	11.7	0	
Sep	3.7	11.0	3.7	7.3	0	
Oct	2.8	8.4	2.6	5.7	0	
Nov	2.0	6.0	2.7	3.3	0	
Dec	1.5	4.6	2.5	2.1	33	17
Totals	***41.5***	***124.2***	***36.1***	***87.9***		***2.1 M gal (8%)***

Table C2. Estimated irrigation capacity during *driest year* since 1979.

Month	Transpiration estimated	Precipitation (infiltrating) 1986	Irrigation Capacity	Overage	
	inches	*inches*	*inches*	*%*	*gpm*
Jan	4.3	0.6	3.7	0	0
Feb	5.3	1.4	3.9	0	0
Mar	9.6	1.7	7.9	0	0
Apr	12.5	0.4	12.0	0	0
May	15.4	0.9	14.4	0	0
Jun	16.1	0.9	15.2	0	0
Jul	16.1	2.7	13.4	0	0
Aug	14.9	6.8	8.1	0	0
Sep	11.0	0.9	10.2	0	0
Oct	8.4	2.7	6.9	0	0
Nov	6.0	3.0	3.0	7.6	3.8
Dec	4.6	3.1	1.5	52	26
Totals	***124.2***	***25.1***	***100.2***		***1.3 M gal (5%)***

Table C-3. Estimated irrigation capacity during *wettest year* since 1979.

Month	Transpiration estimated	Precipitation (infiltrating) 1996	Irrigation Capacity	Overage	
	inches	*inches*	*inches*	*%*	*gpm*
Jan	4.3	3.8	0.5	84	42
Feb	5.3	2.0	3.2	0	0
Mar	9.6	3.7	5.9	0	0
Apr	12.5	3.1	9.3	0	0
May	15.4	3.2	12.1	0	0
Jun	16.1	1.6	14.5	0	0
Jul	16.1	4.0	12.1	0	0
Aug	14.9	4.4	10.5	0	0
Sep	11.0	9.2	1.9	28	14.3
Oct	8.4	3.6	4.8	0	0
Nov	6.0	2.2	3.8	0	0
Dec	4.6	3.3	1.3	60	30
Totals	***124.2***	***44.1***	***79.9***		***3.7 M gal (14%)***

Appendix D

Irrigation System Engineering Diagrams

Seaboard Group II
The City of High Point
Urs Corp.
Seaboard Site
High Point N.C.

August 23 , 2010

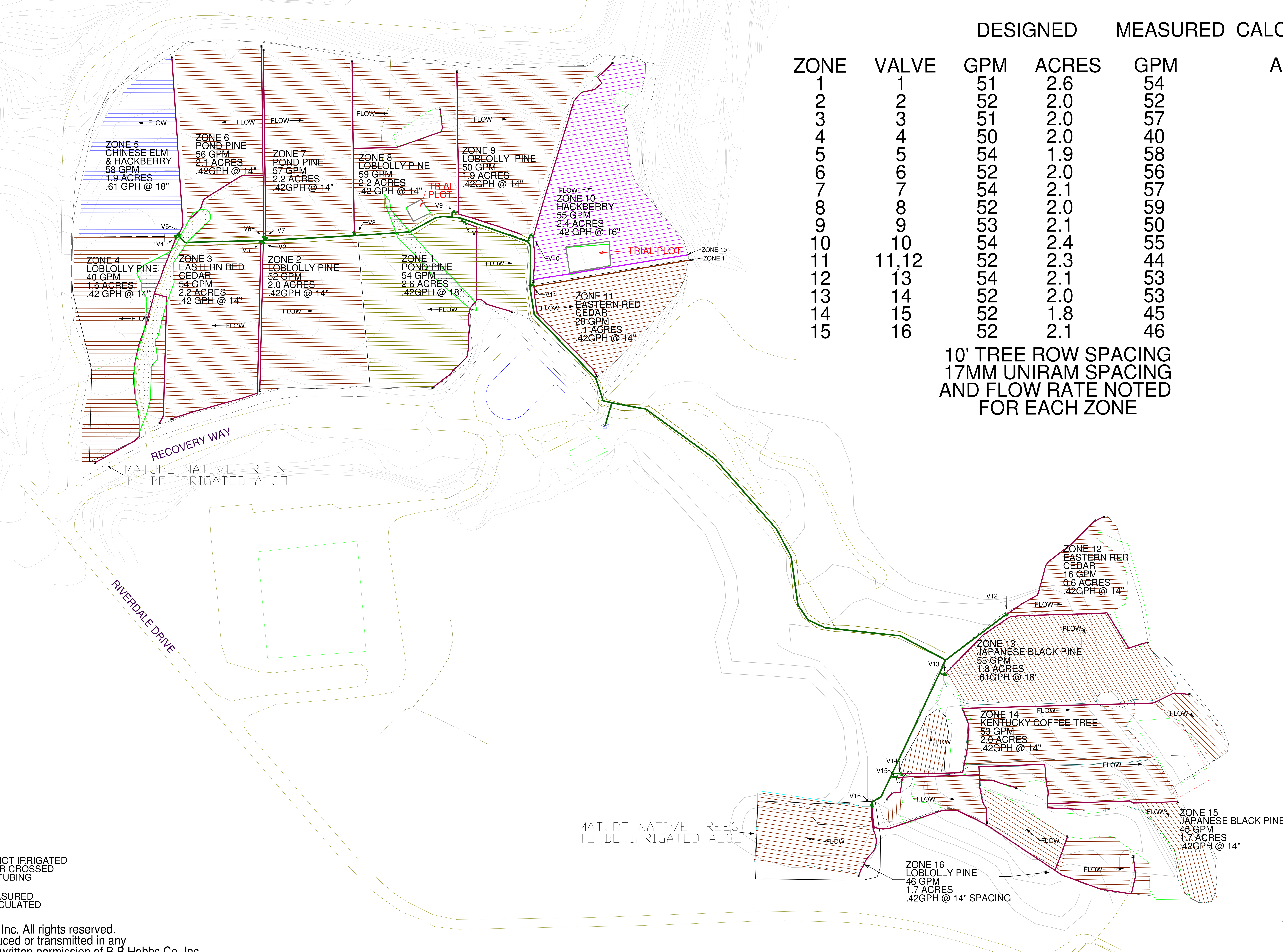
PREPARED BY:
BB HOBBS CO., INC.
PO BOX 1147
DARLINGTON, SC 29540
(843)395-2120

As-built irrigation system
29.84 ACRES
SURFACE DRIP IRRIGATION

29.84 TOTAL NET ACRES

ZONE	VALVE	DESIGNED GPM	DESIGNED ACRES	MEASURED GPM	CALCULATED ACRES
1	1	51	2.6	54	2.62
2	2	52	2.0	52	1.97
3	3	51	2.0	57	2.16
4	4	50	2.0	40	1.60
5	5	54	1.9	58	1.90
6	6	52	2.0	56	2.12
7	7	54	2.1	57	2.16
8	8	52	2.0	59	2.24
9	9	53	2.1	50	1.89
10	10	54	2.4	55	2.37
11	11,12	52	2.3	44	1.67
12	13	54	2.1	53	1.77
13	14	52	2.0	53	2.01
14	15	52	1.8	45	1.70
15	16	52	2.1	46	1.66

10' TREE ROW SPACING
17MM UNIRAM SPACING
AND FLOW RATE NOTED
FOR EACH ZONE



WET AREAS NOT IRRIGATED
NO TUBING OR CROSSED
WITH BLANK TUBING

* REVISED 08/23/2010
TO SHOW ACTUAL MEASURED
FLOW RATES AND CALCULATED
ACERAGES

120 0 60 120

Please Note:
If printed as a non CAD file, i.e. .PDF
use graphic scale to verify true scale

17mm UniRamCNL .42 GPH @ 14"
17mm UniRamCNL .42 GPH @ 16"
17mm UniRamCNL .42 GPH @ 18"
17mm UniRamCNL .61 GPH @ 18"
17MM NETAFIM
2" IPS HDPE Class 160 Pipe
3" IPS HDPE Class 160 Pipe

1.5"DOROT Bronze Press. Red. Valve TT
2" SUBMAIN FLUSH ASSEMBLY
UniRam .4 GPH
Water Supply

IRRIGATION DESIGN~SALES~SERVICE~INSTALLATION

BB HOBBS IRRIGATION FERTIGATION COMPANY
B.B. HOBBS COMPANY
P.O. BOX 1147
DARLINGTON, SC 29540
PHONE: 843-395-2120
FAX: 843-393-3595
E-MAIL: irrigate@bbhobbs.com

B.B. HOBBS COMPANY - FL
1611 18TH AVE. DR EAST
PALMETTO, FL 34221
PHONE: 941-722-3433
FAX: 941-722-4330
E-MAIL: irrigate@bbhobbs.com

DESIGNER: Floyd Finch III
APPROVED:
DATE: 15 October 2009
REV: 15 October 2009

B.B. HOBBS COMPANY, INC.

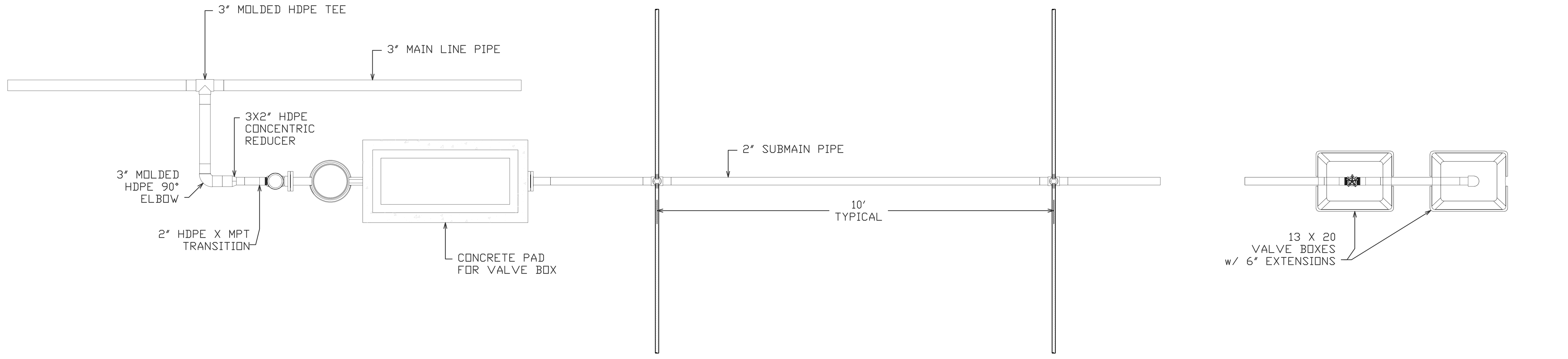
Seaboard Group II & City of High Point

Seaboard Phytoremdiation Final Layout

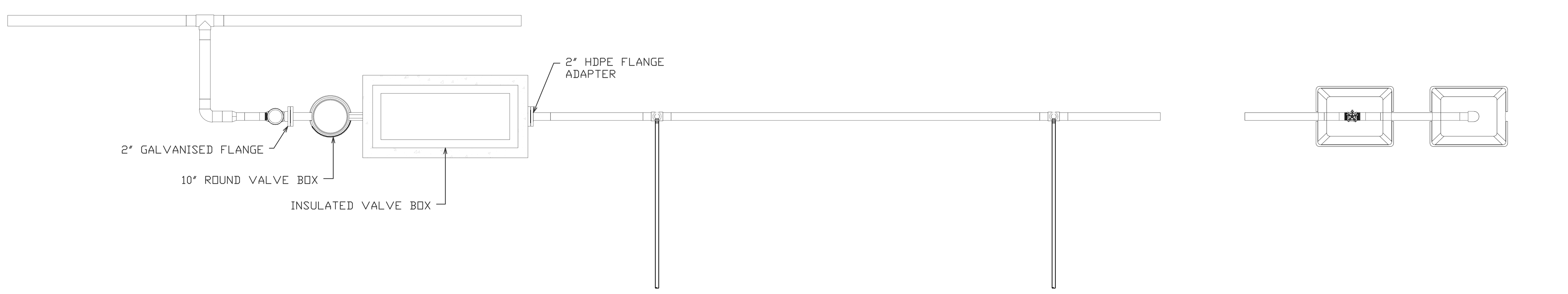
1" = 120'

File: Seaboard Site Oct

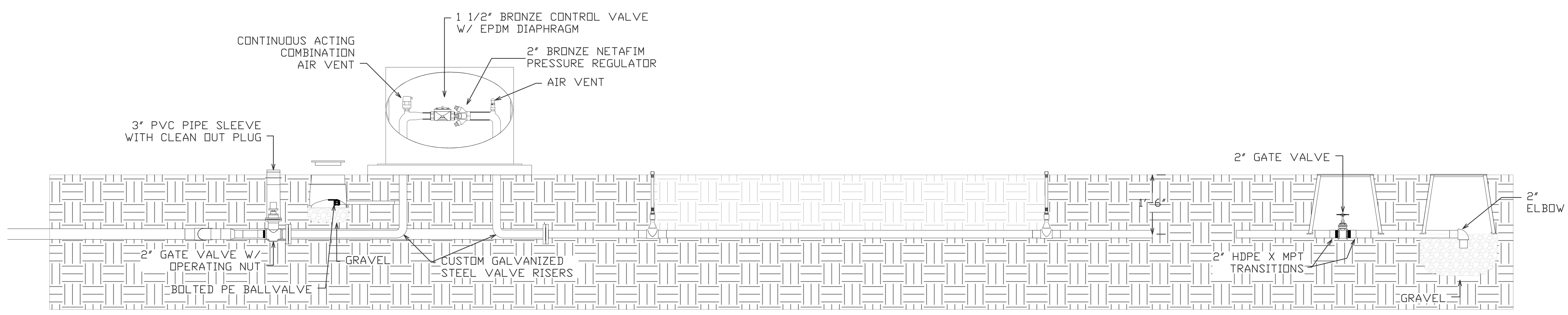
TOP VIEW TWO WAY FEED



TOP VIEW ONE WAY FEED

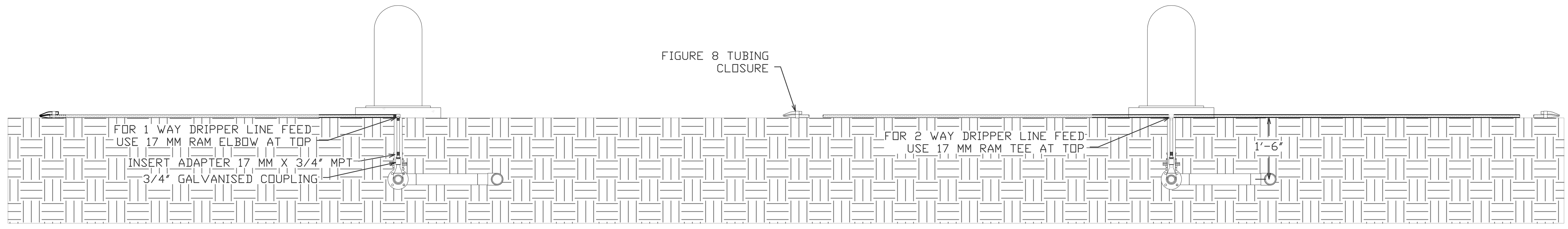


ELEVATION VIEW TYPICAL



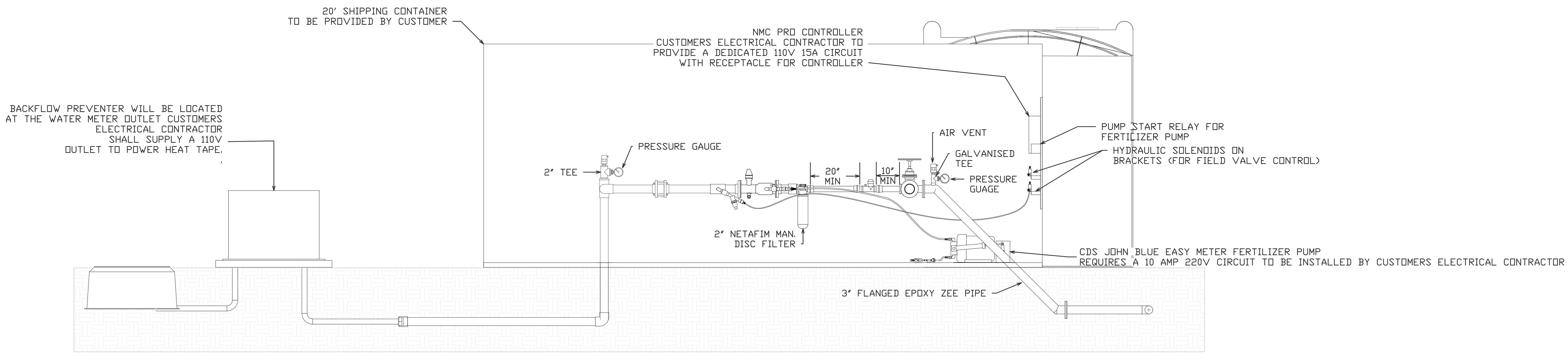
TUBING & RISER ASSEMBLY ONE WAY FEED

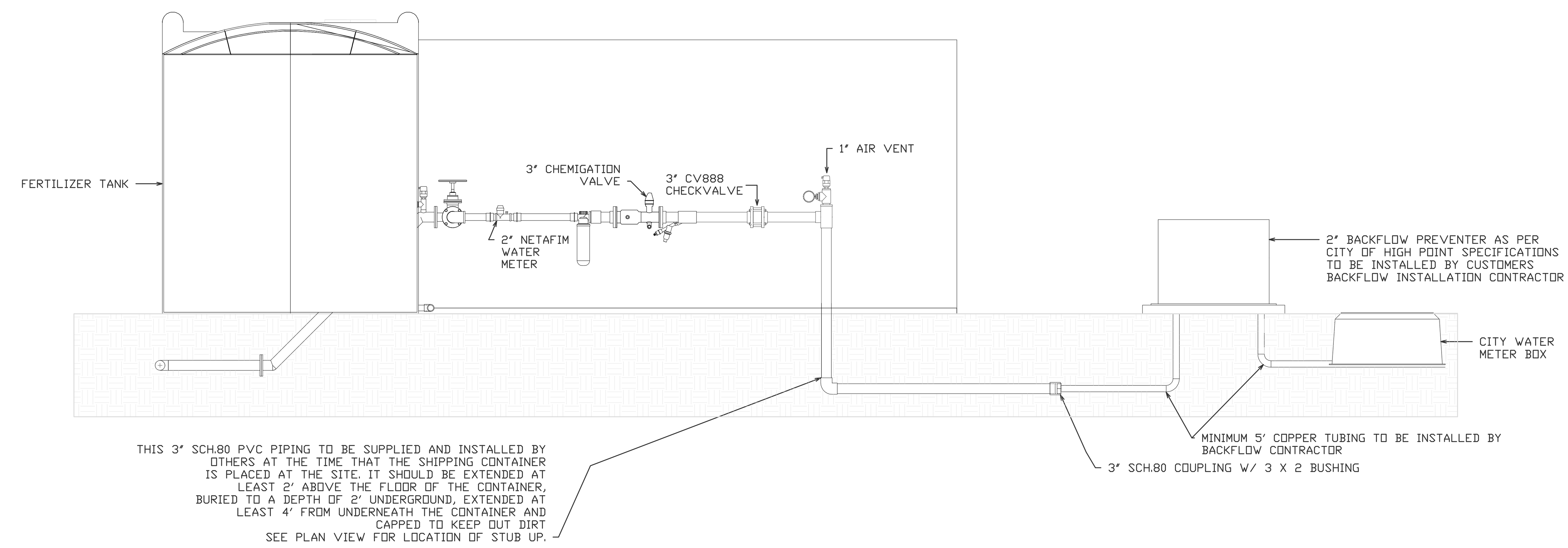
TUBING & RISER ASSEMBLY TWO WAY FEED

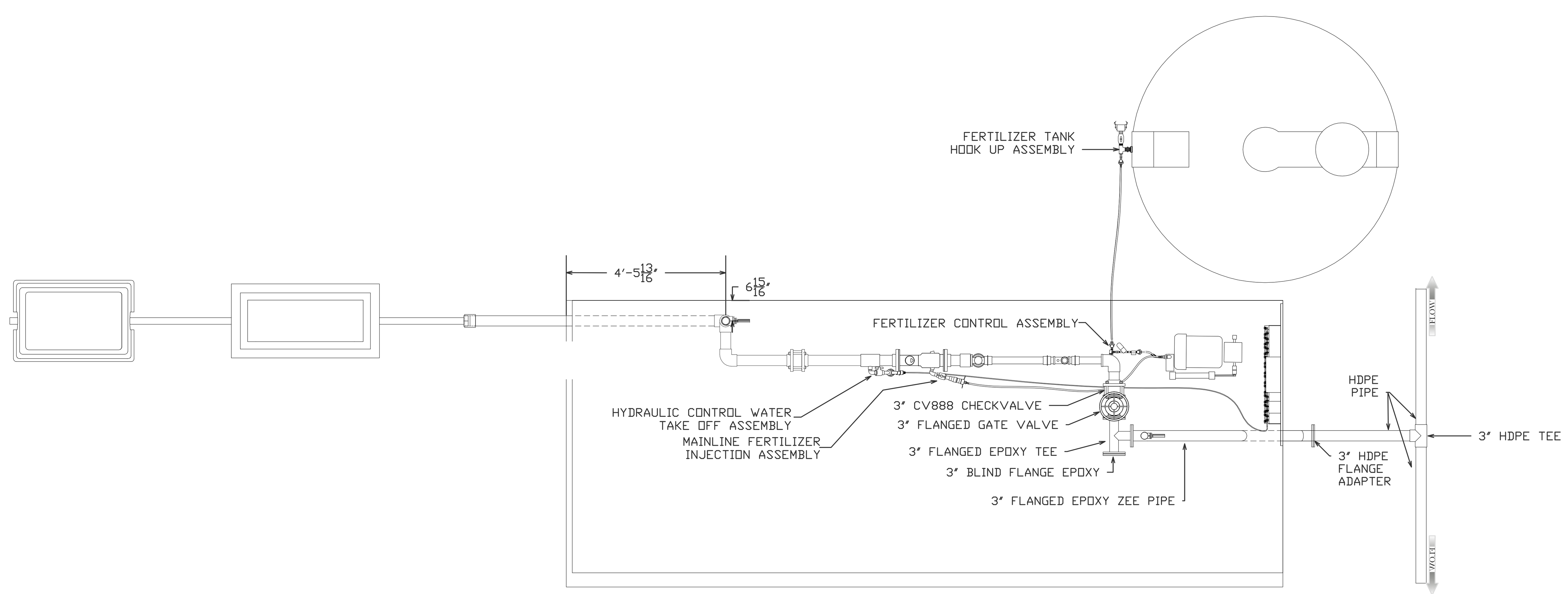


Sheet # 2 of 5	Date: 10-14-09 Scale: NTS	Designed by: Floyd Finch III Reviewed by: your name here	REVISIONS BY 11-09-09 FF 11-20-09 FF 12-06-09 FF 12-09-09 FF	Surface Drip Remediation Plan Field Plumbing Assy. Details	PREPARED FOR: Seaboard Group 2 & The City of High Point High Point, N.C.

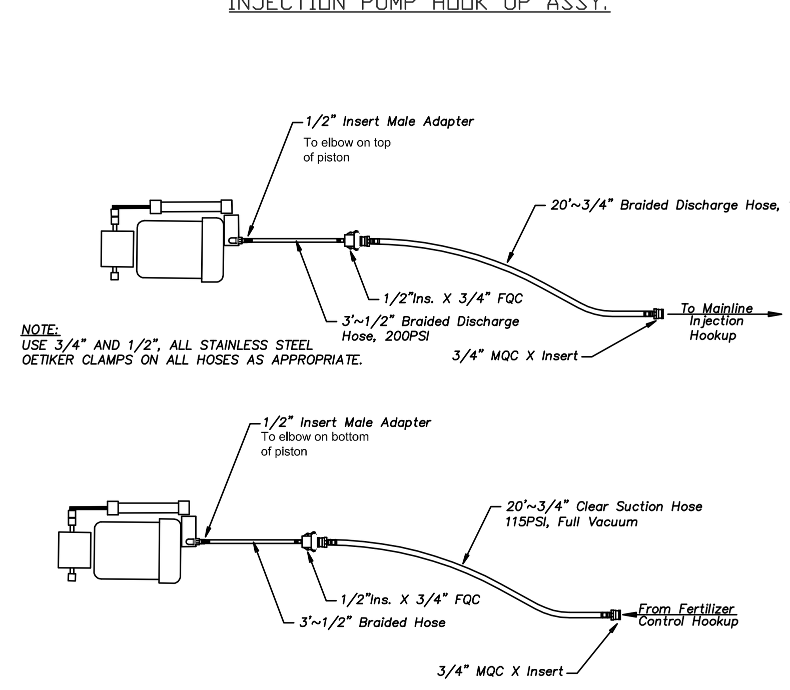
BB HOBBS COMPANY
BB Hobbs Co. Inc.
P.O.Box 1147 Darlington, S.C. 29540
Phone (843) 395 2120 Fax(843) 393 3595
www.bbhobbs.com



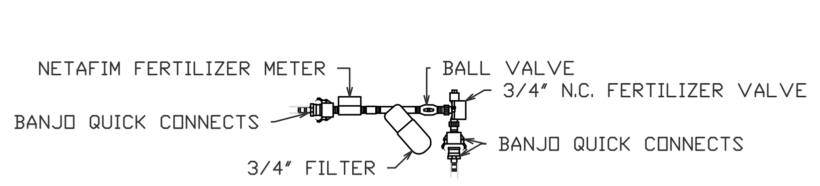




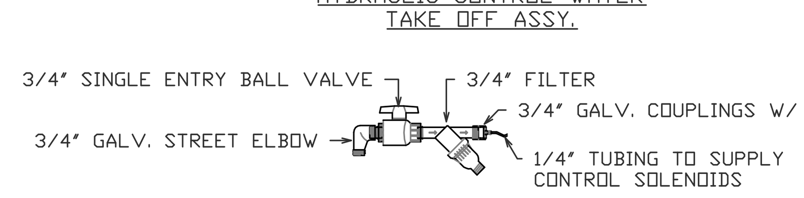
INJECTION PUMP HOOK UP ASSY.



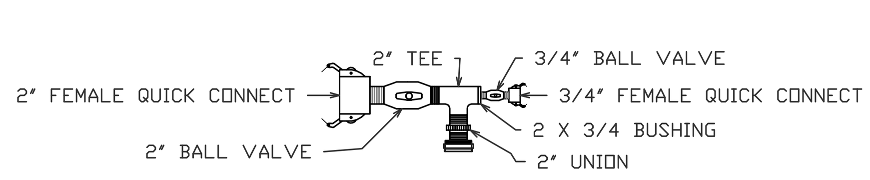
FERTILIZER CONTROL ASSY.



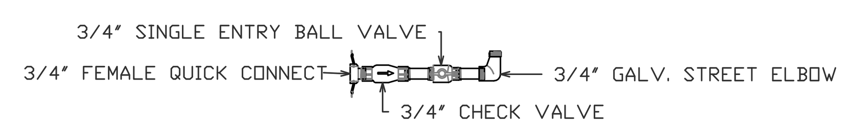
HYDRAULIC CONTROL WATER
TAKE OFF ASSY.



FERT. TANK HOOK UP ASSY.

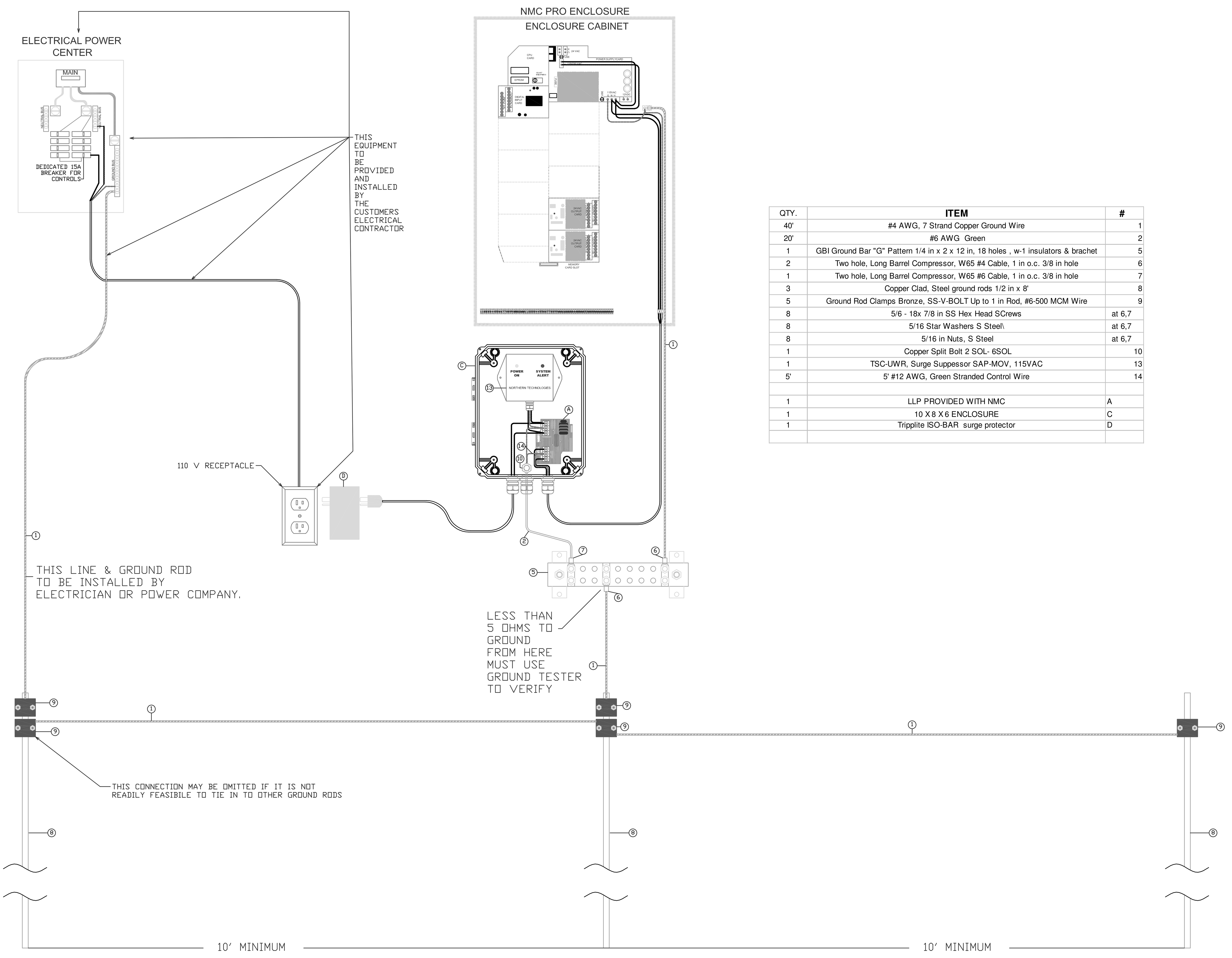


MAIN LINE FERT. INJECTION ASSY.



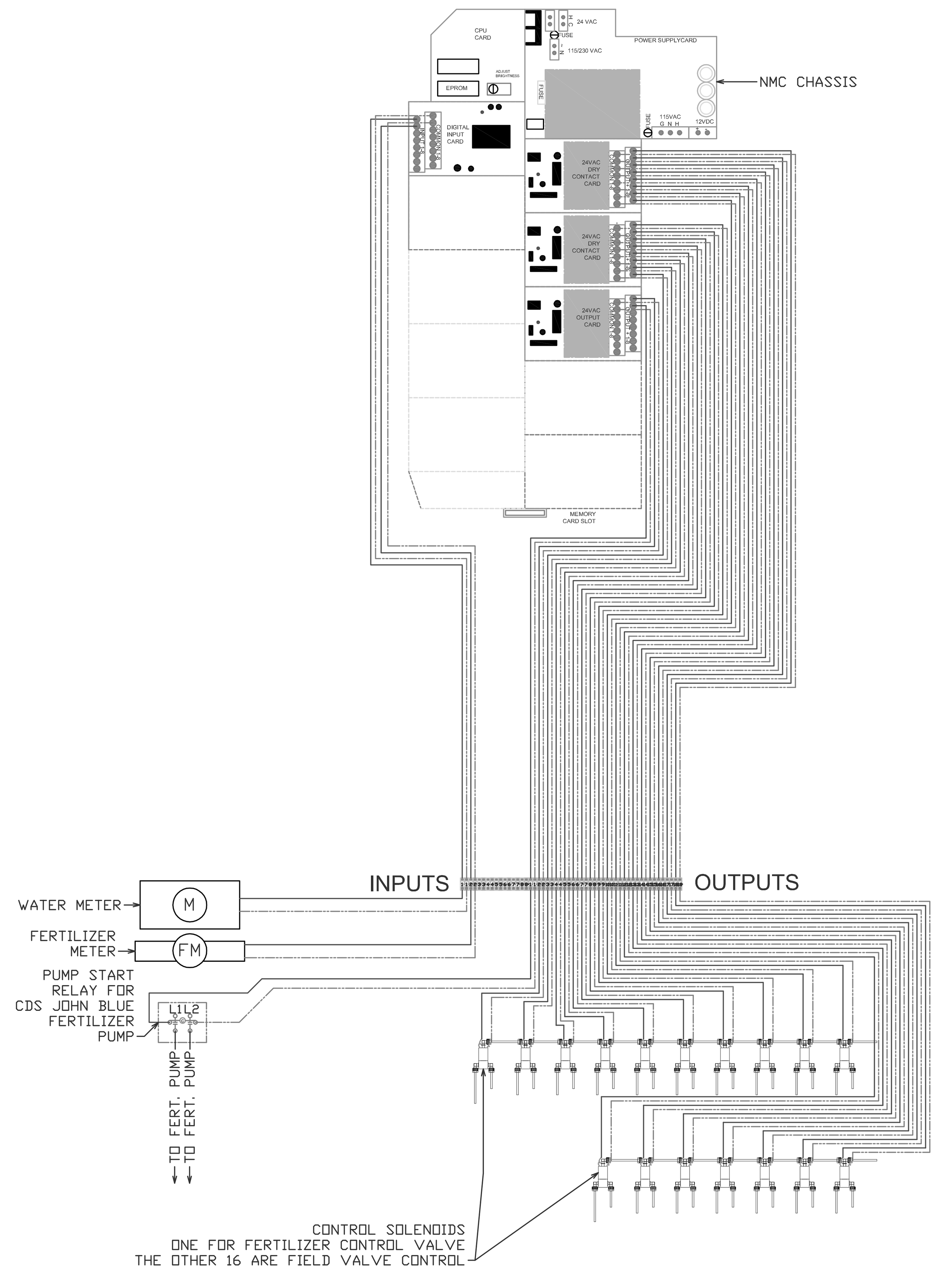
Sheet # 3 of 5	Date: 10-19-09	Designed by: Floyd Finch III	REVISIONS BY: 11-09-09 FF	Surface Drip Irrigation Plan Filter, Fertilizer, & Control Station Seaboard Site High Point, N.C.	PREPARED FOR: Seaboard Group II & The City of High Point	BB HOBBS IRRIGATION COMPANY	BB Hobbs Co. Inc. P.O.Box 1147 Darlington, S.C. 29540 Phone (843) 395 2120 Fax(843) 393 3595 www.bbhobbs.com
	Scale: NTS	Reviewed by: KCS					

POWER CONNECTION, LIGHTNING PROTECTION AND GROUNDING SCHEMATIC

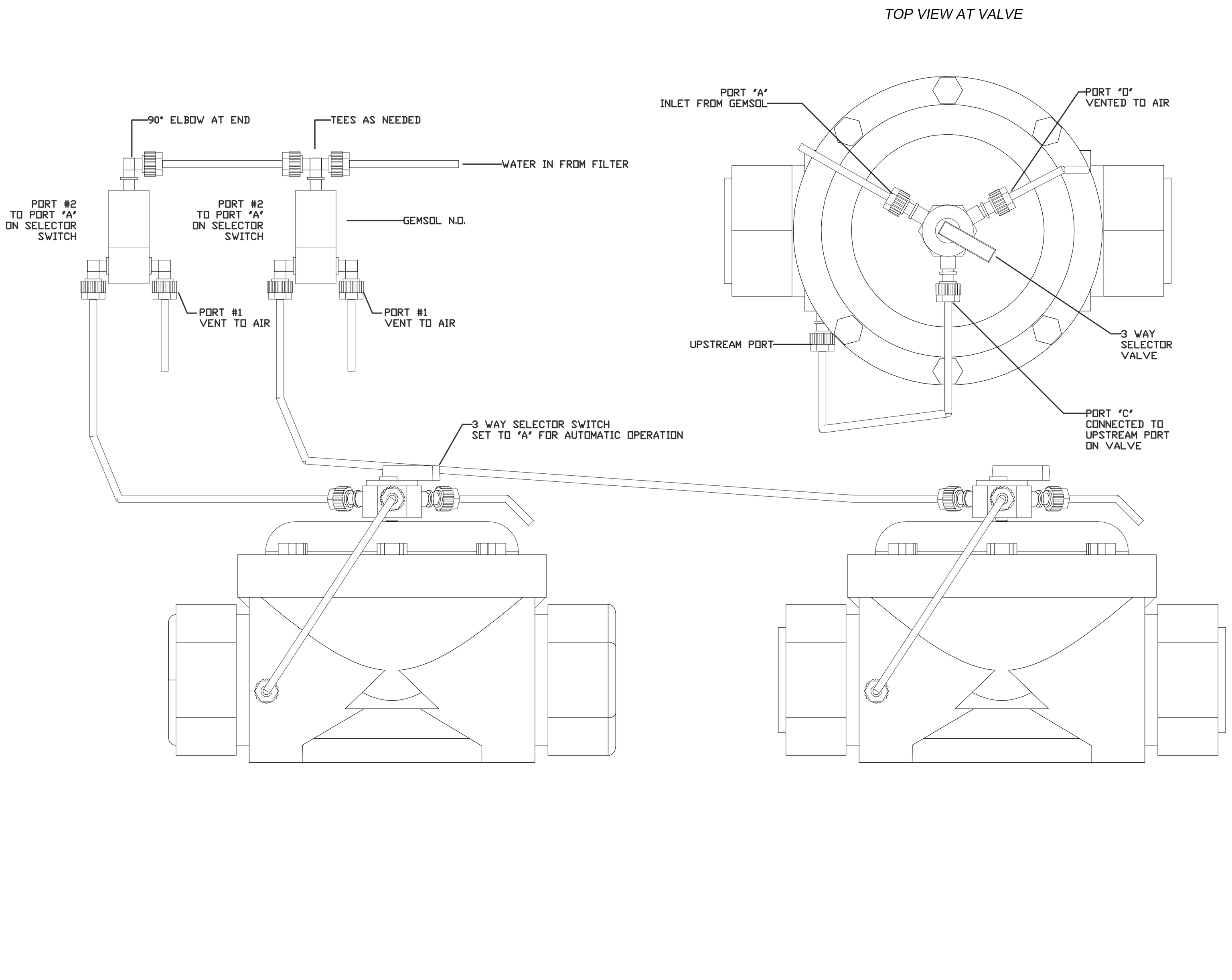


QTY.	ITEM	#
40'	#4 AWG, 7 Strand Copper Ground Wire	1
20'	#6 AWG Green	2
1	GBI Ground Bar "G" Pattern 1/4 in x 2 x 12 in, 18 holes , w-1 insulators & brachet	5
2	Two hole, Long Barrel Compressor, W65 #4 Cable, 1 in o.c. 3/8 in hole	6
1	Two hole, Long Barrel Compressor, W65 #6 Cable, 1 in o.c. 3/8 in hole	7
3	Copper Clad, Steel ground rods 1/2 in x 8'	8
5	Ground Rod Clamps Bronze, SS-V-BOLT Up to 1 in Rod, #6-500 MCM Wire	9
8	5/6 - 18x 7/8 in SS Hex Head SCrews	at 6,7
8	5/16 Star Washers S Steel\	at 6,7
8	5/16 in Nuts, S Steel	at 6,7
1	Copper Split Bolt 2 SOL- 6SOL	10
1	TSC-UWR, Surge Suppessor SAP-MOV, 115VAC	13
5'	5' #12 AWG, Green Stranded Control Wire	14
1	LLP PROVIDED WITH NMC	A
1	10 X 8 X 6 ENCLOSURE	C
1	Tripplite ISO-BAR surge protector	D

WATER METER, FERTILIZER METER AND SOLENOIDS CONNECTIONS SCHEMATIC



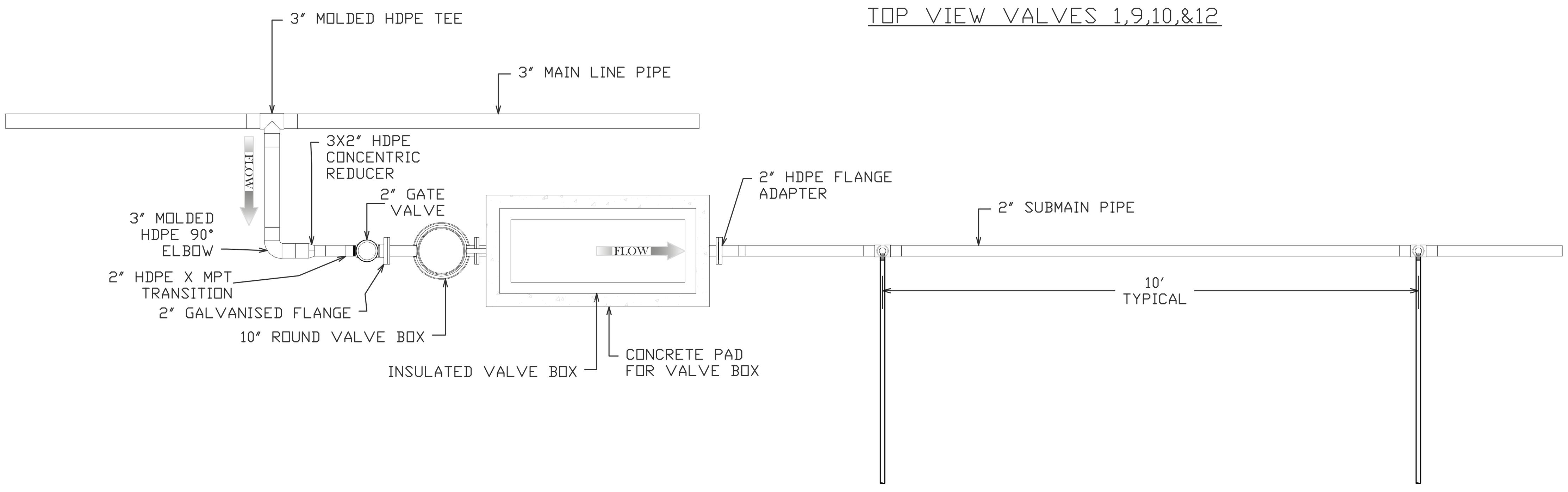
HYDRAULIC CONTROL WATER SCHEMATIC



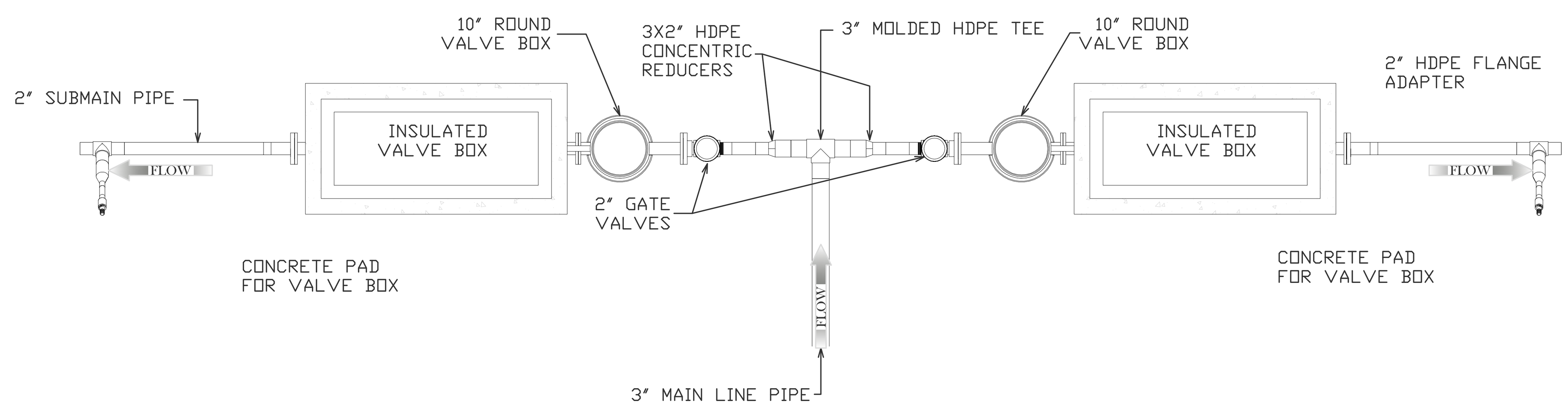
Sheet # 4 of 5	Date: 08-22-09	Designed by: Lloyd Finch III	REVISIONS	BY:	Surface Drip Irrigation Plan Wiring & Hydraulic Control Schematics Seaboard Site High Point, N.C.	PREPARED FOR: Seaboard Group II & The City of High Point	BB Hobbs Co. Inc.
	Scale: NTS	Reviewed by: KCS					

BB Hobbs Co. Inc.
P.O.Box 1147 Darlington, S.C. 29540
Phone (843) 395 2120 Fax(843) 393 3595
www.bbhobbs.com

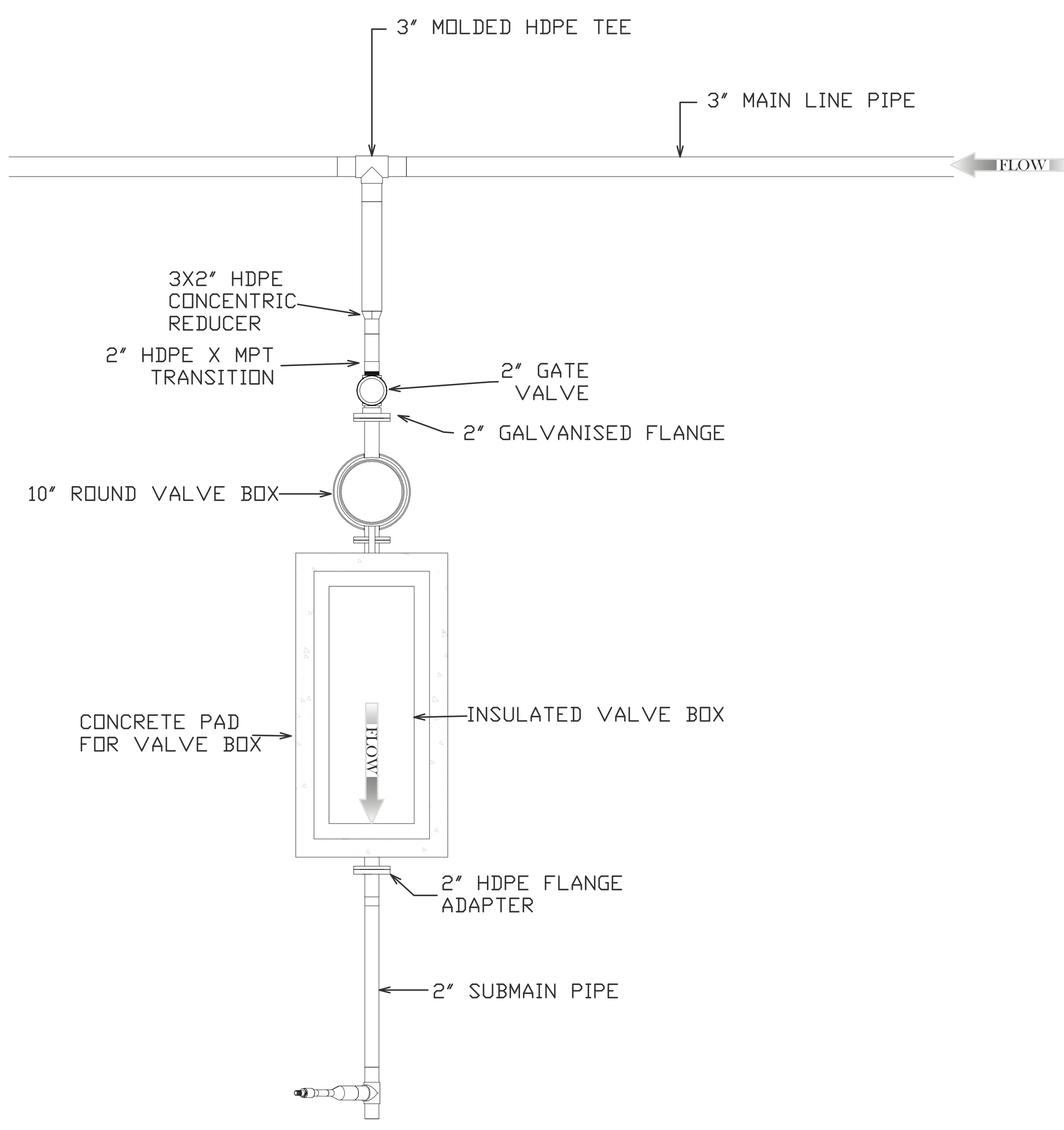
TOP VIEW VALVES 1,9,10,&12



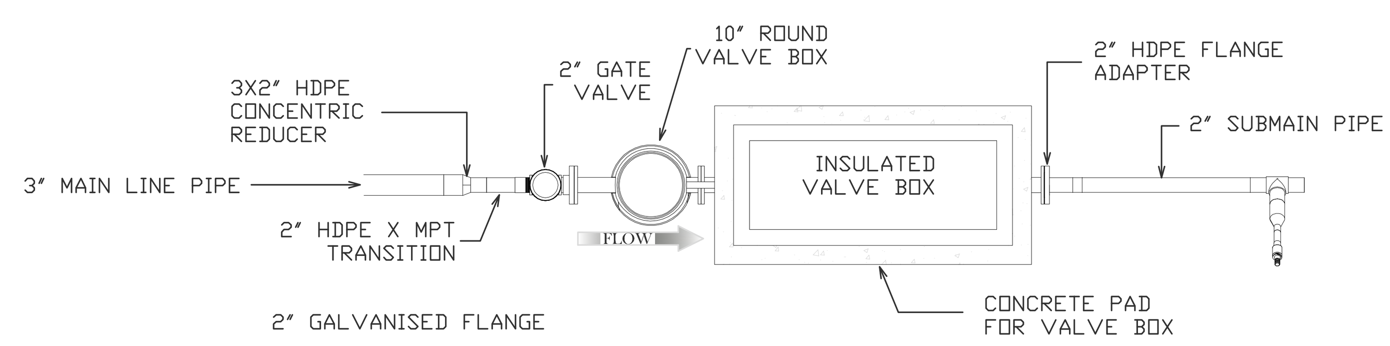
TOP VIEW VALVES 4&5



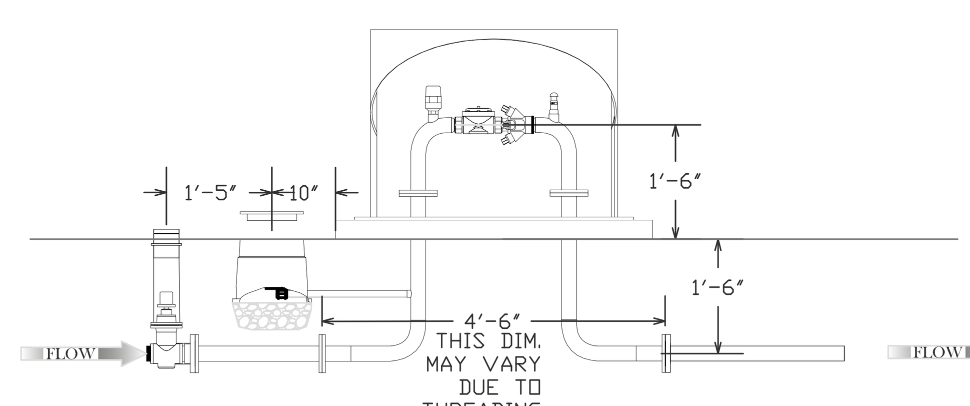
TOP VIEW VALVES 2,3,6,7,13,14,&11A



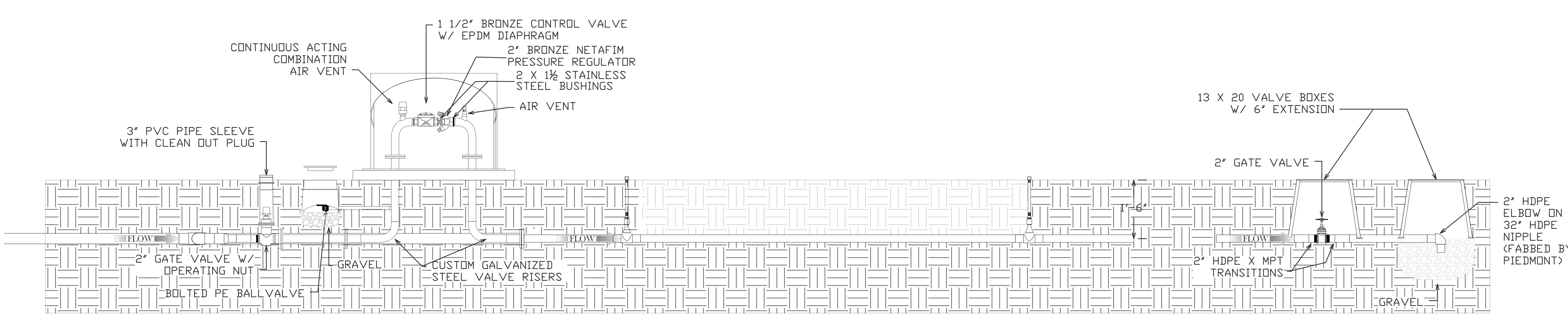
TOP VIEW VALVES 11B & 15



ELEVATION VIEW W/ DIMENSIONS



ELEVATION VIEW TYPICAL



(IN FEET)
1 inch = 2 ft.

Sheet # 5 of 5	Date: 12-06-09 Scale: 1"=2'	Designed by: Lloyd Finch III Reviewed by: your name here	REVISIONS BY	Surface Drip Remediation Plan Field Valve Assembly Plans (addendum for construction crew use)

PREPARED FOR:
Seaboard Group 2 &
The City of High Point
High Point, N.C.

BB HOBBS COMPANY
BB Hobbs Co. Inc.
P.O.Box 1147 Darlington, S.C. 29540
Phone (843) 395 2120 Fax(843) 393 3595
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Appendix E

Irrigation System Component Specifications

AIR VENTS

COMBINATION AIR/VACUUM AND CONTINUOUS ACTING AIR VENTS

PROVEN DESIGN PROVIDES MORE AIR RELEASE CAPACITY THAN OTHER VENTS OF SIMILAR SIZES

2″ COMBINATION
Air/Vacuum and
Continuous Acting Air Vent

2″ COMBINATION
Air Release/Vacuum Guard and
Continuous Acting Air Vent

1″ COMBINATION
Air/Vacuum and
Continuous Acting Air Vent

¾″ & 1″ AUTOMATIC
Continuous Acting
Air Vent

¾″ & 1″ AUTOMATIC
Continuous Acting
Vacuum Guard Air Vent

PRODUCT ADVANTAGES

- Ensures maximum protection of irrigation system with proper sizing and placement.
- Aerodynamic float design ensures vent closure as water fills the system, remains open when air pressure reaches 12 psi.
- Large capacity vents dampen water hammer preventing pipes and fittings from cracking or bursting.
- Unique patented rolling seal feature allows gradual opening, closing and self-cleaning.
- Made of corrosion-resistant reinforced UV protected nylon - no metal parts to rust or corrode, no need for spare parts.

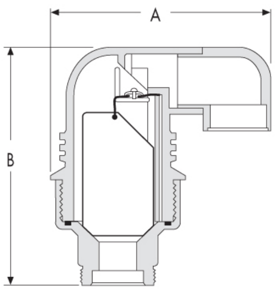
APPLICATIONS

- **1″ & 2″ COMBINATION AIR/VACUUM AND CONTINUOUS ACTING AIR VENTS**
  - For discharge of large volumes of air: pump and filtration stations, along mains, at the end of mainlines.
  - At high points in pipe network or upstream of manifolds.
  - Every 1,000 feet along mainlines 6 inches and larger.
- **2″ COMBINATION AIR RELEASE/VACUUM GUARD & CONTINUOUS ACTING AIR VENT**
  - Releases air at pump priming and maintains the prime by not allowing air intake in long and/or undulating suction lines to pump stations.
  - Releases entrapped air while ensuring continuous prime at centrifugal pumps.
  - Builds up siphons with air release, maintains the siphon by continuously releasing air and not allowing air intake.
- **¾″ & 1″ AUTOMATIC CONTINUOUS ACTING AIR VENTS**
  - For high spots where air accumulates.
- **¾″ & 1″ CONTINUOUS ACTING/VACUUM GUARD AIR VENT**
  - For release of entrapped air while ensuring continuous pump prime with no air intake in centrifugal pumps and pump suction lines.
  - Protects mechanical seals in vertical pumps by not allowing air to accumulate in the stuffing boxes.
  - Maintain siphons with continuous air release while not allowing air intake.

SPECIFICATIONS

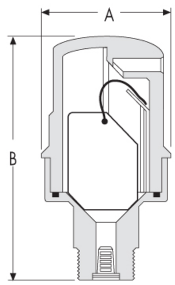
- Maximum operating pressures:
  - 1″, 2″ Nylon Combination: 230 psi
  - 2″ Polypropylene Combination: 150 psi
  - ¾″ & 1″ Automatic: 230 psi
- Five year warranty

COMBINATION AIR/VACUUM AND CONTINUOUS ACTING AIR VENTS



COMBINATION AIR/VACUUM AND CONTINUOUS ACTING AIR VENT
STAGES OF OPERATION

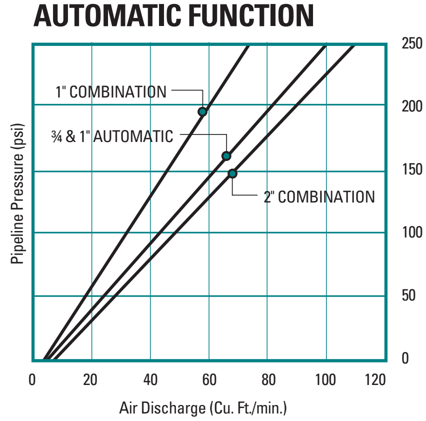
1. During start-up, the air vent discharges large volumes of air.
2. As the system builds pressure, the body fills with water, forcing the float upwards and closing the air vent.
3. While the system is pressurized, the "automatic" function continuously releases accumulated air.
4. At shutdown, the air vent's large opening allows air back into the system preventing the pipe and accessories from collapsing, and preventing suction of mud and debris.



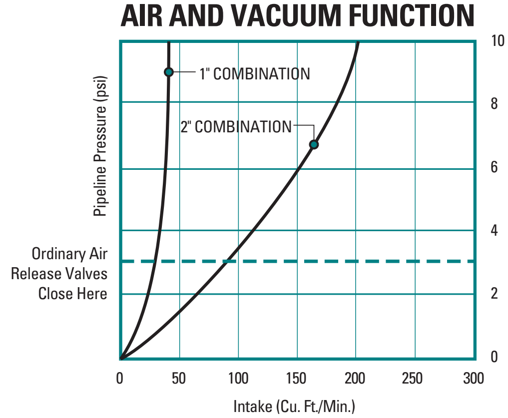
AUTOMATIC CONTINUOUS ACTING AIR VENT
STAGES OF OPERATION

1. While the system is pressurized, air accumulates in the body, systematically dropping the rolling seal mechanism releasing the trapped air.
2. After air is released, water again enters the body and forces the float to close the air vent.

AUTOMATIC FUNCTION



AIR AND VACUUM FUNCTION



DIMENSIONS & WEIGHT

	MODEL NUMBER	NOMINAL SIZE	DIMENSION A	DIMENSION B	WEIGHT	CONNECTION
2″ Nylon Combination (Plastic Base)	65ARIB2	2″	7.09″	8.23″	2.35 lbs	2″ NPT Male Thread
2″ Nylon Combination (Brass Base)	65ARIB2-B	2″	7.09″	8.23″	4.75 lbs	2″ NPT Male Thread
2″ Polypropylene Combination (Plastic Base)	65ARIB2PP	2″	7.09″	8.23″	1.90 lbs	2″ NPT Male Thread
2″ Polypropylene Combination (Brass Base)	65ARIB2-BPP	2″	7.09″	8.23″	3.80 lbs	2″ NPT Male Thread
2″ Nylon Combination Vacuum Guard	65ARIB2VM	2″	8.09″	8.23″	2.50 lbs	2″ NPT Male Thread
1″ Combination	65ARIB1	1″	3.93″	5.51″	0.66 lbs	1″ NPT Male Thread
1″ Combination (Brass Base)	65ARIB1-B	1″	3.93″	5.51″	1.54 lbs	1″ NPT Male Thread
¾″ Automatic	65ARIS075	¾″	3.20″	5.51″	0.56 lbs	¾″ NPT Male Thread
¾″ Automatic Vacuum Guard	65ARIS075VM	¾″	3.20″	5.51″	0.56 lbs	¾″ NPT Male Thread
1″ Automatic	65ARIS1	1″	2.95″	5.51″	0.65 lbs	1″ NPT Male Thread
1″ Automatic Vacuum Guard	65ARIS1VM	1″	3.20″	5.51″	0.66 lbs	1″ NPT Male Thread

NETAFIM™
GROW MORE WITH LESS

NETAFIM USA
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Fresno, CA 93727
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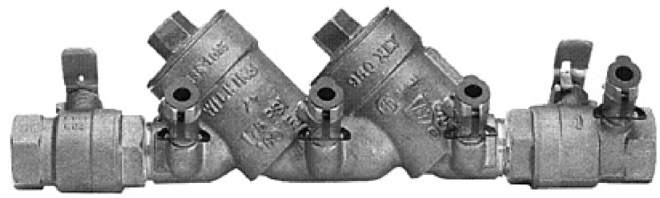
A043 03/09

Model 950XLT

Top Access Double Check Valve Assembly

SPECIFICATION SUBMITTAL SHEET



APPLICATION

Designed for installation on potable water lines to protect against both backsiphonage and backpressure of polluted water into the potable water supply. A tethered test cock cap is provided to protect against fouling caused by insects, dirt and debris. Assembly shall provide protection where a potential non-health hazard exists.

FEATURES

Sizes: ❑3/4" ❑ 1" ❑ 1 1/4" ❑ 1 1/2" ❑ 2"

Maximum working water pressure	175 PSI
Maximum working water temperature	180°F
Hydrostatic test pressure	350 PSI
End connections Threaded	ANSI B1.20.1

STANDARDS COMPLIANCE

(Unless otherwise noted, applies to 3/4" thru 2" Horizontal)

- ASSE® Listed 1015 (Vertical flow-up:1 1/4" thru 2")
- IAPMO® Listed
- AWWA Compliant C510
- CSA® Certified (Vertical flow-up:1 1/2" & 2")
- NYC MEA 426-89-M VOL 3
- Approved by the Foundation for Cross Connection Control and Hydraulic Research at the University of Southern California

OPTIONS

(Suffixes can be combined)

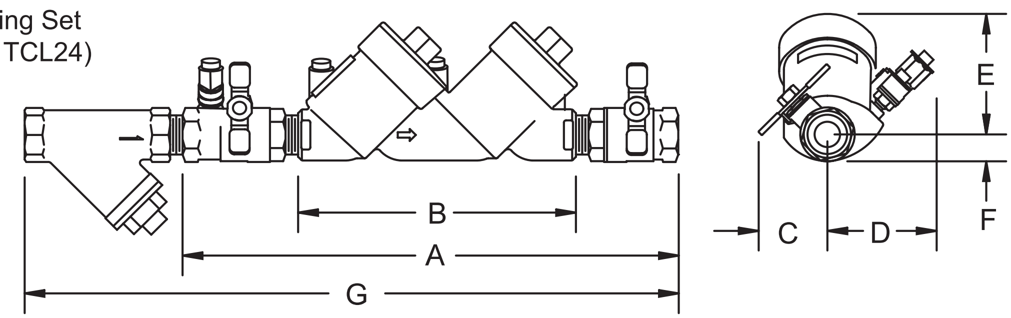
❑ L - less ball valves
❑ FT - with "Fast Test" test cocks
❑ U - with union ball valves
❑ S - with bronze "Y" type strainer

MATERIALS

Main valve body	Cast Bronze ASTM B 584
Access covers	Cast Bronze ASTM B 584
Fasteners	Stainless Steel, 300 Series
Elastomers	Silicone (FDA approved) Buna Nitrile (FDA approved)
Polymers	Noryl™, NSF Listed
Springs	Stainless steel, 300 series
Test cock cover	Plastic

ACCESSORIES

❑ Repair kit (rubber only)
❑ Thermal expansion tank (Model WXTP)
❑ Bronze wye strainer
❑ Stainless steel ball valve handles
❑ QT-SET Quick Test Fitting Set
❑ Test Cock Lock (Model TCL24)



DIMENSIONS & WEIGHTS (do not include pkg.)

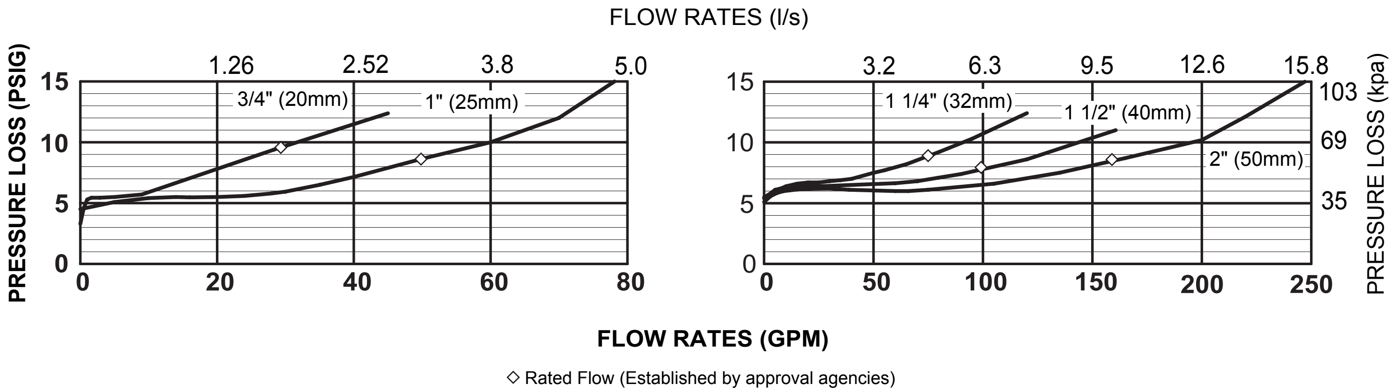
MODEL SIZE		DIMENSIONS (approximate) A		A UNION BALL VALVES		B LESS BALL VALVES		C		D		E		F		G		WEIGHT LESS BALL VALVES		WITH BALL VALVES	
in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kg	lbs.	kg
3/4	20	13	330	14 5/16	364	8 3/4	222	2 3/8	60	2 5/16	59	3 5/16	84	3/4	19	17 5/8	448	4	1.8	6	2.7
1	25	14	356	15 3/4	400	8 3/4	222	2 1/2	64	2 5/16	59	3 5/16	84	3/4	19	19 3/4	502	8	3.6	12	5.4
1 1/4	32	19 5/8	499	21 5/8	549	13 3/4	349	4	102	3 5/8	92	4 3/8	111	1 5/16	33	24 3/4	629	16	7.3	22	10
1 1/2	40	20 5/16	516	22 5/16	567	13 3/4	349	5 3/8	137	3 5/8	92	4 3/8	111	1 5/16	33	25 15/16	659	16	7.3	22	10
2	50	21 3/8	543	23 1/4	591	13 3/4	349	5 13/16	148	3 5/8	92	4 3/8	111	1 5/16	33	28 5/16	719	17	7.7	29	13.2

DOCUMENT #: BF-950XLT REVISION: 1/09

WILKINS a Zurn company, 1747 Commerce Way, Paso Robles, CA 93446 Phone:**805/238-7100** Fax:**805/238-5766**
In Canada: ZURN INDUSTRIES LIMITED, 3544 Nashua Dr., Mississauga, Ontario L4V 1L2 Phone:**905/405-8272** Fax:**905/405-1292**
Product Support Help Line: 1-877-BACKFLOW **(1-877-222-5356)** • **Website: http://www.zurn.com**

FLOW CHARACTERISTICS

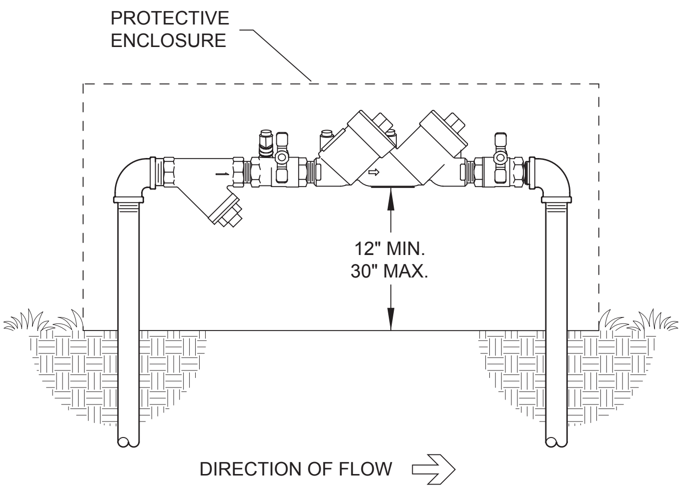
MODEL 950XLT 3/4", 1", 1 1/4", 1 1/2" & 2" (STANDARD & METRIC)



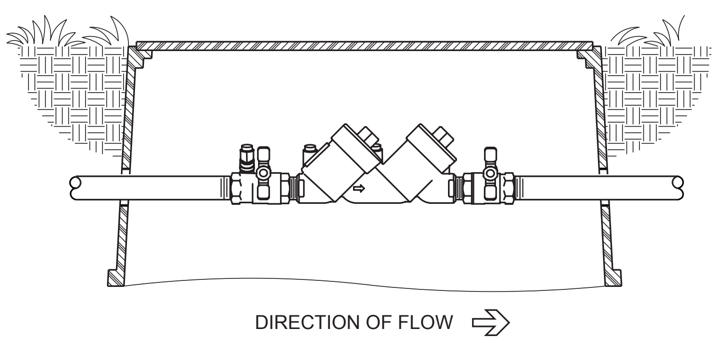
TYPICAL INSTALLATION

Local codes shall govern installation requirements. To be installed in accordance with the manufacturer's instructions and the latest edition of the Uniform Plumbing Code. Unless otherwise specified, the assembly shall be mounted at a minimum of 12" (305mm) and a maximum of 30" (762mm) above adequate drains with sufficient side clearance for testing and maintenance. If installed below grade, be certain adequate drainage is provided to prevent the device from being submerged.

Capacity thru Schedule 40 Pipe				
Pipe size	5 ft/sec	7.5 ft/sec	10 ft/sec	15 ft/sec
1/8"	1	1	2	3
1/4"	2	2	3	5
3/8"	3	4	6	9
1/2	5	7	9	14
3/4"	8	12	17	25
1"	13	20	27	40
1 1/4"	23	35	47	70
1 1/2"	32	48	63	95
2"	52	78	105	167



OUTDOOR INSTALLATION



PIT INSTALLATION

SPECIFICATIONS

The Double Check Type Backflow Preventer shall be ASSE Listed 1015, rated to 180°F and supplied with full port ball valves. The main body and access covers shall be bronze (ASTM B 584), the seat ring and all internal polymers shall be NSF® Listed Noryl™ and the seat disc elastomers shall be SILICONE. The first and second check shall be located at a 45° angle and accessible for maintenance from the top of the device, without removing the device from the line. Each check shall have separate access covers and test cocks shall be accessible from the top of the device. Test cocks shall be protected from debris by a tethered cap. The Double Check Type Backflow Preventer shall be a WILKINS Model 950XLT.

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IN CANADA: ZURN INDUSTRIES LIMITED, 3544 Nashua Dr., Mississauga, Ontario L4V 1L2 Phone:**905/405-8272** Fax:**905/405-1292**
Product Support Help Line: 1-877-BACKFLOW **(1-877-222-5356)** • **Website: http://www.zurn.com**

N E T A F I M

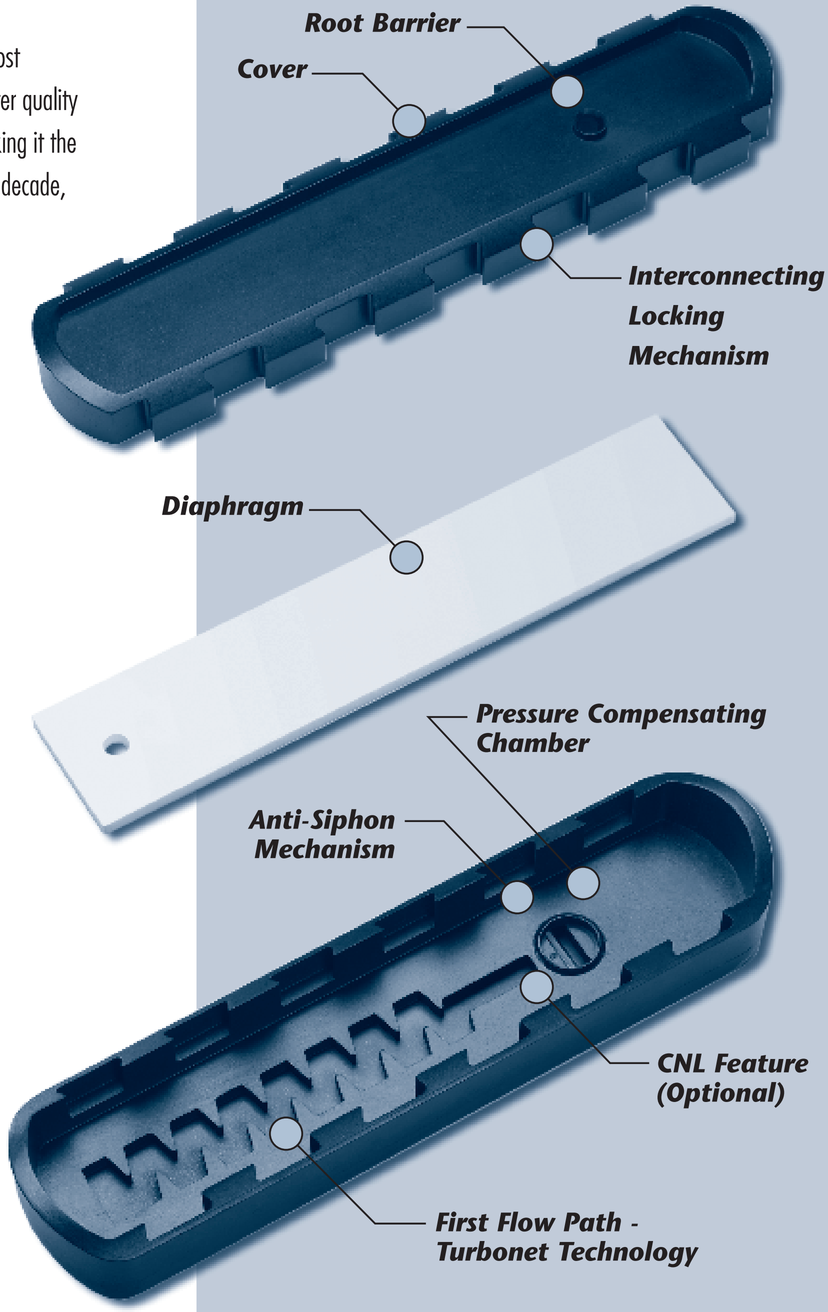
UniRam Heavywall Dripperline

The Ultimate Solution for Drip Irrigation

NETAFIM™
GROW MORE WITH LESS

Applications and Specifications

Thirty-seven years of Netafim experience shows itself - UniRam is the most advanced technology available today. Developed for extremely poor water quality and rolling terrains, UniRam's dripper design maximizes uniformity, making it the ultimate solution for sub-surface applications. For the fourth consecutive decade, Netafim leads the way with this revolutionary product.



Applications

- For surface or sub-surface applications
- For Agriculture, Greenhouse & Nursery, Landscape and Wastewater
- Ideal for high frequency irrigation in undulating terrain
- For poor water-quality conditions

Specifications

Inside diameter: .540" (16mm, 45 mil)
.570" (17mm, 45 mil)
.620" (18mm, 45 mil)
.690" (20mm, 48 mil)
.820" (60 mil)

Nominal flow rates (GPH): 0.26, 0.42, 0.53, 0.61, 0.92, 1.00

Common spacings: 18", 24", 30", 36", 42", 48", 60"
(Custom spacings also available)

Regulating pressure: 7 to 58 psi

Recommended filtration: 120 mesh

PACKAGING DATA

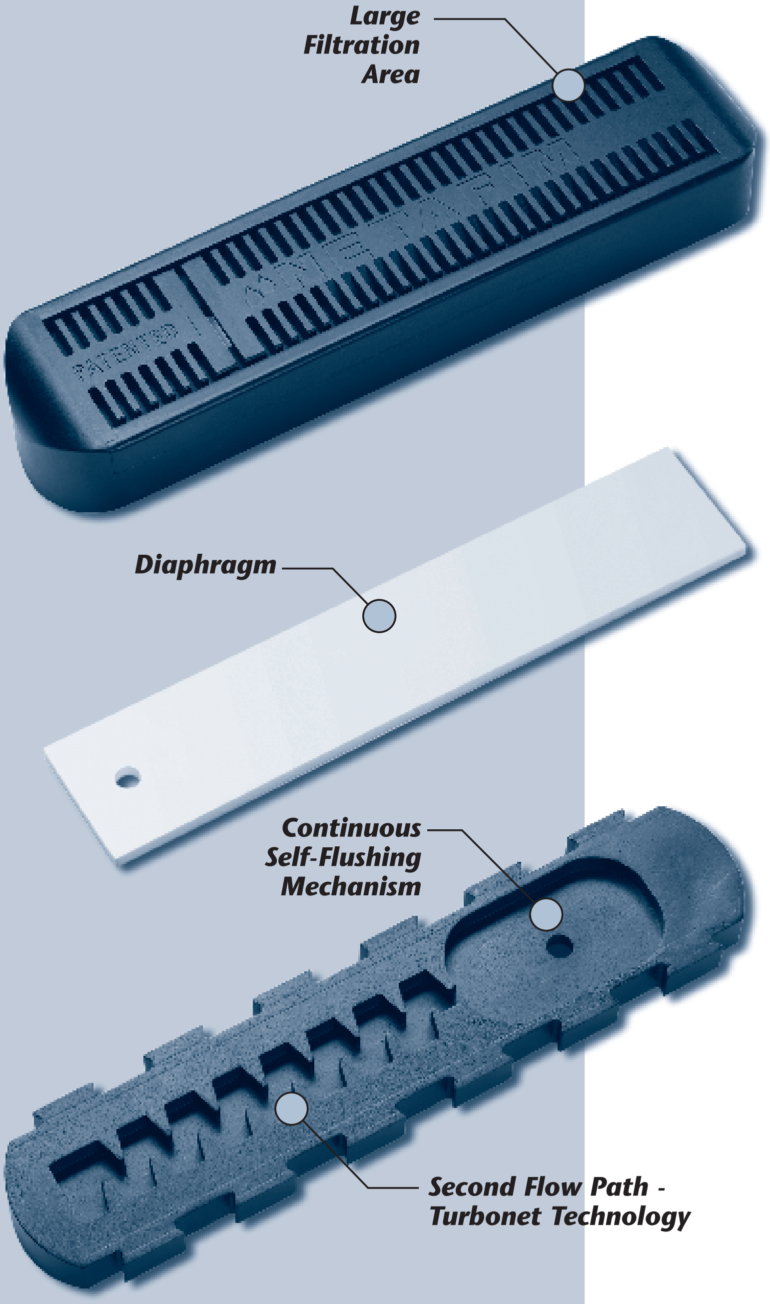
Tubing I.D.	Mil	Reel Length	Weight	Kd
.540	45	1,000'	35 lbs	1.60
.570	45	1,000'	37 lbs	1.20
.620	45	1,000'	40 lbs	0.85
.690	48	1,000'	49 lbs	0.40
.820	60	1,000'	69 lbs	0.30

20 coils per pallet.

DRIPPER FLOW PATH DIMENSIONS

Dripper	Length	Depth	Width	Filtration Area
0.26	1.574"	0.029"	0.033"	0.2015 sq. in.
0.42	1.574"	0.028"	0.050"	0.2015 sq. in.
0.53	1.574"	0.028"	0.050"	0.2015 sq. in.
0.61	1.574"	0.039"	0.050"	0.2015 sq. in.
0.92	1.575"	0.045"	0.063"	0.2325 sq. in.
1.00	1.575"	0.045"	0.063"	0.2325 sq. in.

Product Advantages



Anti-Siphon Mechanism
Built-in root intrusion barrier and anti-vacuum mechanism prevents suction of dirt into the dripperline, providing the critical protection you need against dripper plugging.

Wide Compensating Range
Wide compensating range maintains a constant uniform flow – longer runs and steep terrains are irrigated with high uniformity.

Exclusive Non-Leakage (CNL) Mechanism - Optional
Prevents system drainage when pressure is turned off at the end of each irrigation cycle. Ensures uniform water distribution during pulse irrigation.

Widest Flow Path - Ultimate Clog Resistance
Operates in extremely poor water quality conditions - designed with two wide flow paths allowing larger particles to pass through, preventing plugging.

- Self-flushing mechanism continuously flushes dripper during operation.

Root Intrusion Barrier
Prevents roots from penetrating the dripper's mechanism. Ideal for sub-surface irrigation.

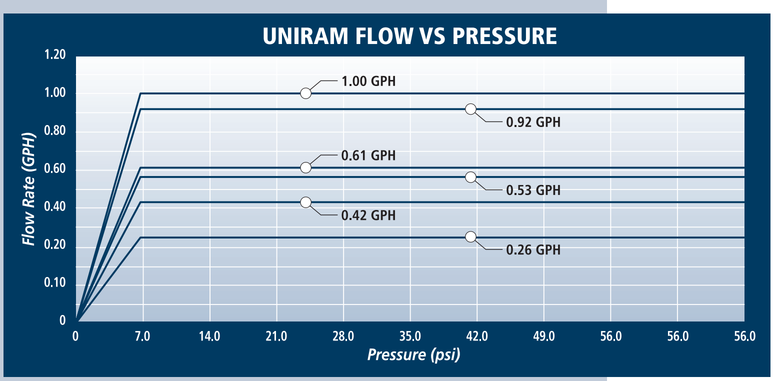
Large Filtration Area
Entire base of the UniRam dripper is made of filter inlets - flushing large particles from the dripper, eliminating clogging and maintaining an essential supply of water for uninterrupted operation.

Diaphragm
Made of chemical-resistant silicon.

TURBONET

Commonly used turbulent drippers have overlapping tooth patterns, easily catching debris.

Turbonet Technology
Improves dripper performance by widening the tooth pattern, maximizing flow path velocity, allowing contaminants to pass easily through the dripper, virtually eliminating plugging.



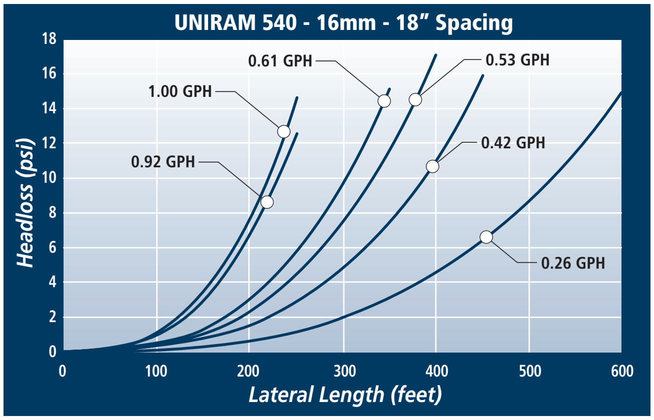
VineLine Vineyard Solutions

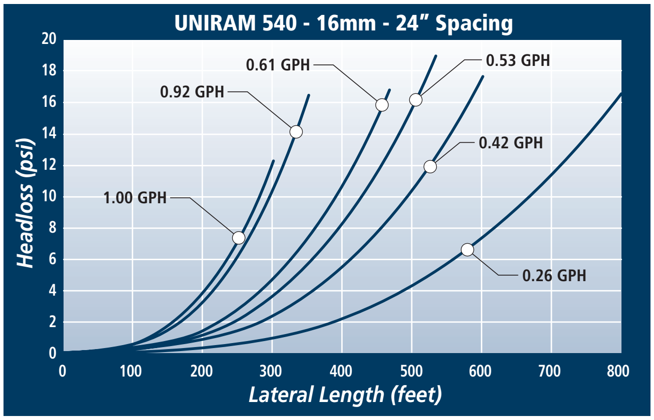
Pre-Installed Adjustable Dripperline Ring

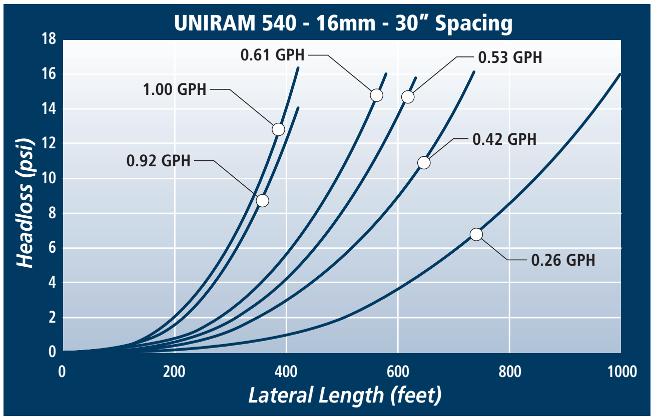
Ordering Tip - *When placing your order, add a V before the U in the Part Number.*

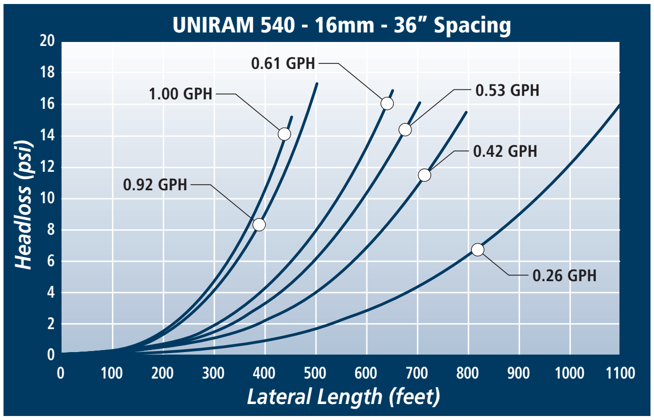
- Easily adjustable – moves from one end of the dripperline to the other preventing water migration
- Economical – saves labor costs
- Flexible options – available with Ram or Triton Heavywall Dripperlines
- Available for .540, .570, .620 and .690 sizes.

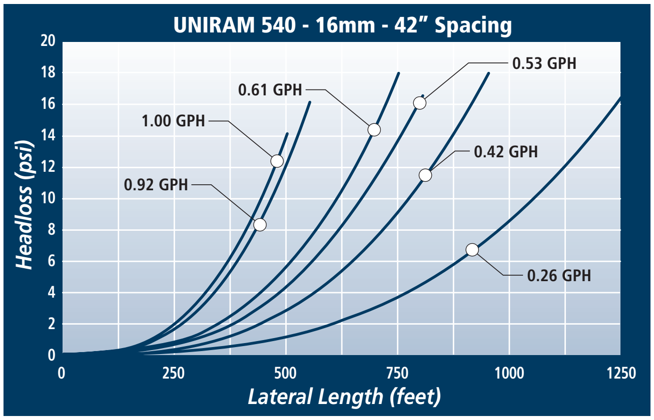
UniRam .540" (16mm, 45 mil) Headloss and Lateral Length

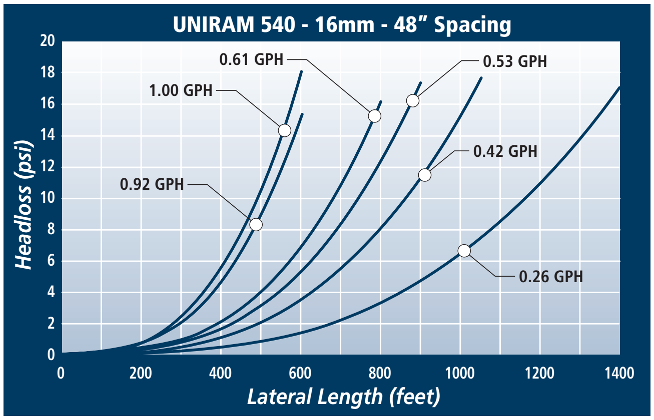


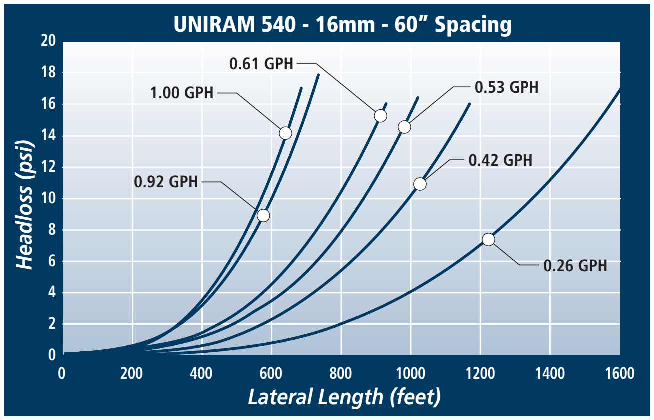












EQUATION TO CALCULATE LATERAL LENGTH INLET PRESSURE

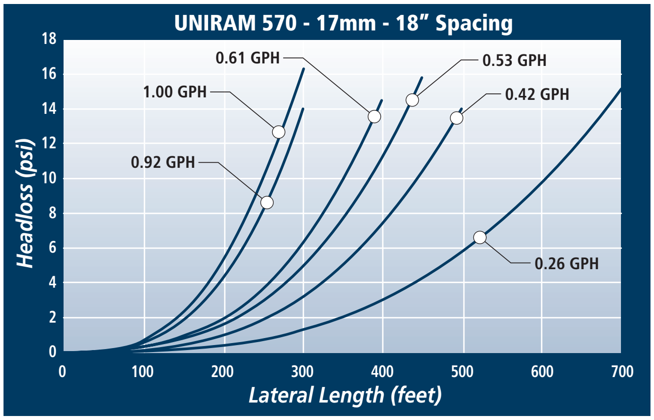
Line End Pressure* *(10 psi)*
\+ Pressure Loss *(derived from charts)*
= Inlet Pressure

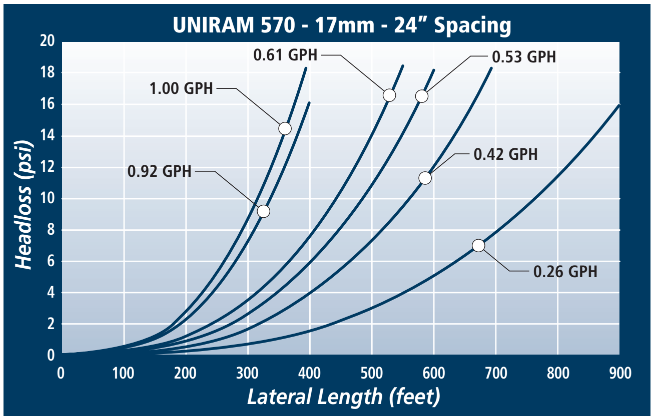
**Minimum pressure at lateral length end = 10 psi.*

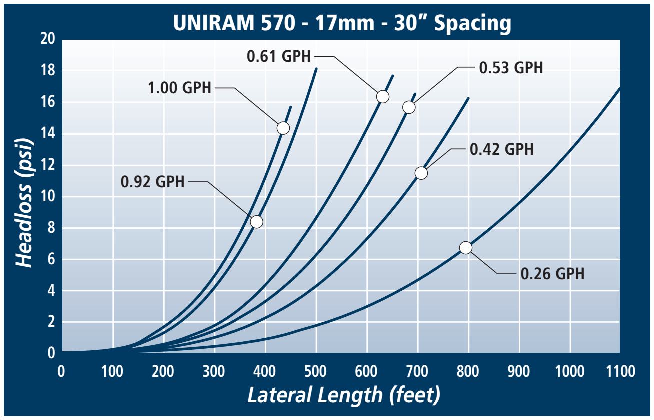
Example:

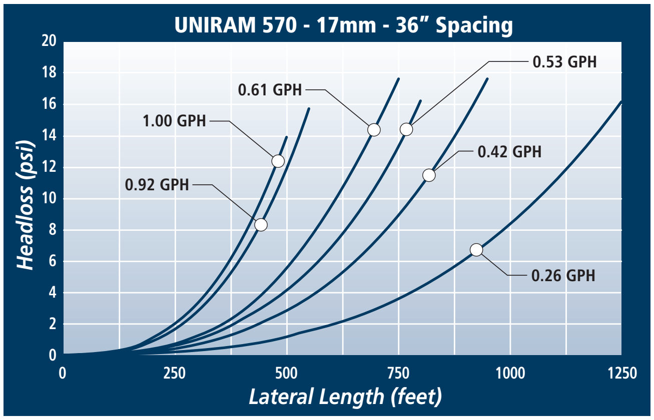
UniRam .540"	**10 psi** *(end pressure)*
400' Run	+ **11 psi** *(from graph)*
0.42 GPH Flow Rate	= **21 psi**
18" Spacing	

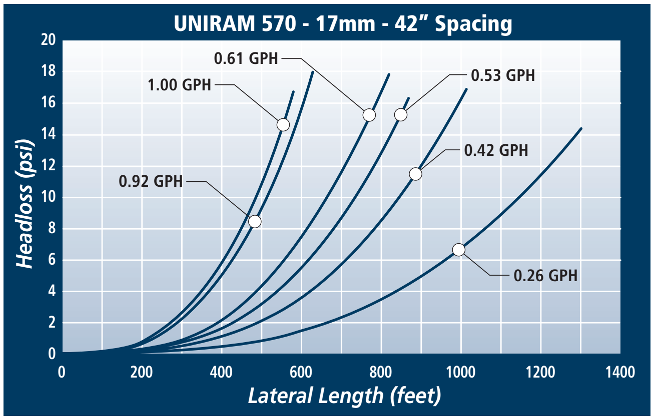
UniRam .570" (17mm, 45 mil) Headloss and Lateral Length

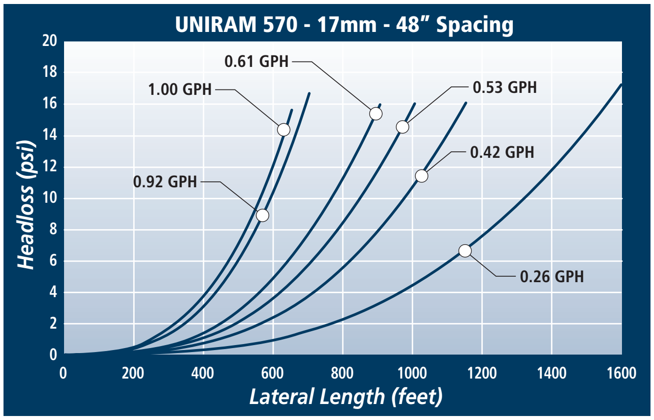


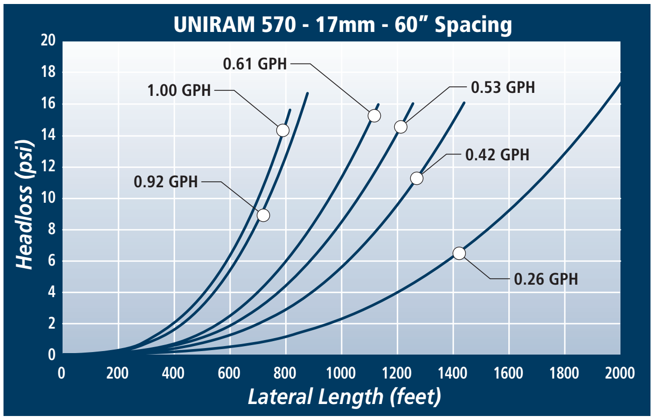












EQUATION TO CALCULATE LATERAL LENGTH INLET PRESSURE

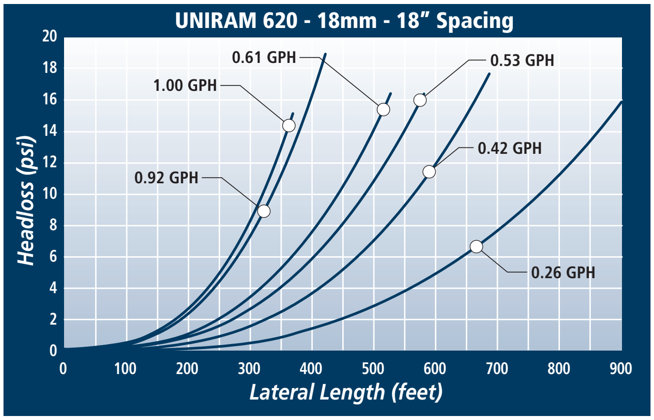
Line End Pressure* *(10 psi)*
+ **Pressure Loss** *(derived from charts)*
= **Inlet Pressure**

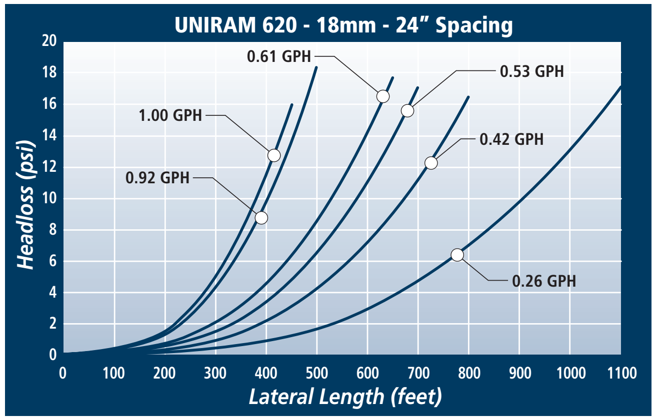
**Minimum pressure at lateral length end = 10 psi.*

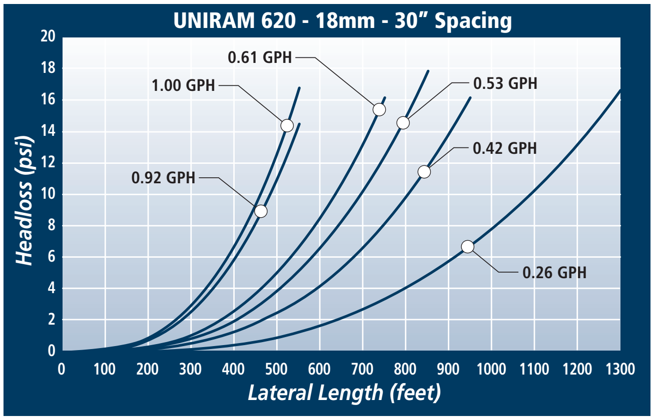
Example:

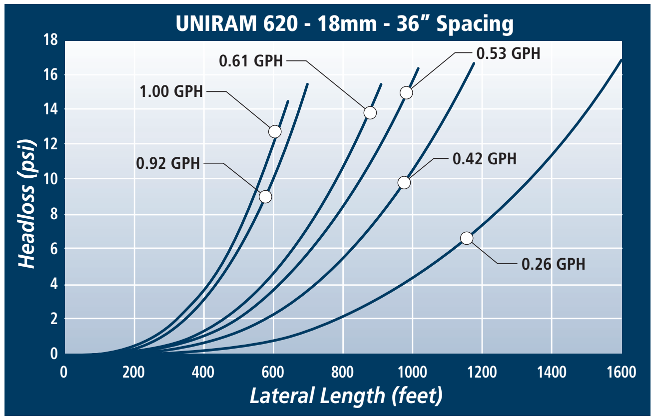
UniRam .570"	**10 psi** *(end pressure)*
450' Run	+ **11 psi** *(from graph)*
0.42 GPH Flow Rate	= **21 psi**
18" Spacing	

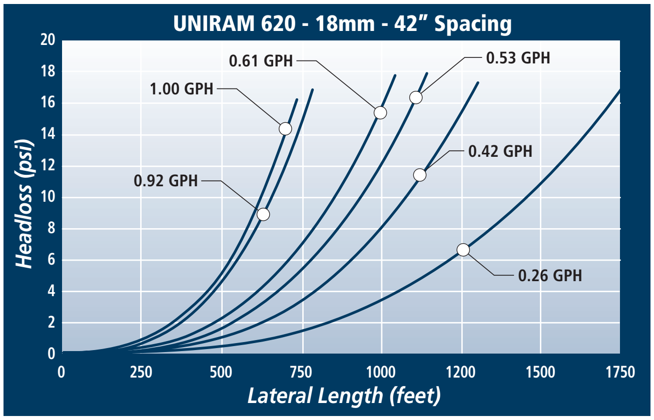
UniRam .620” (18mm, 45 mil) Headloss and Lateral Length

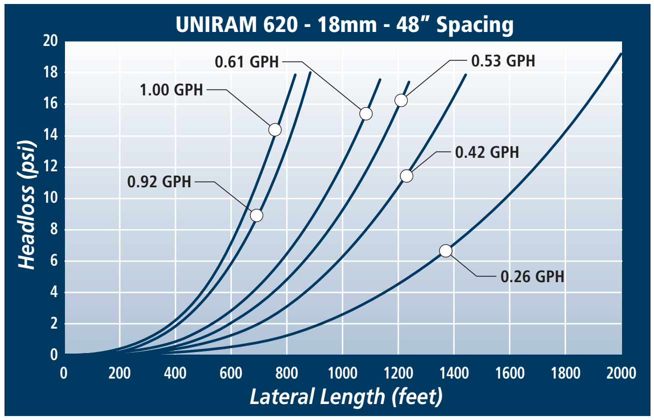


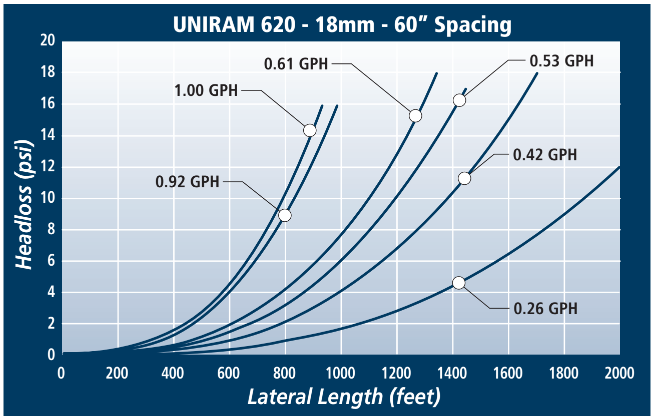












EQUATION TO CALCULATE
LATERAL LENGTH INLET PRESSURE

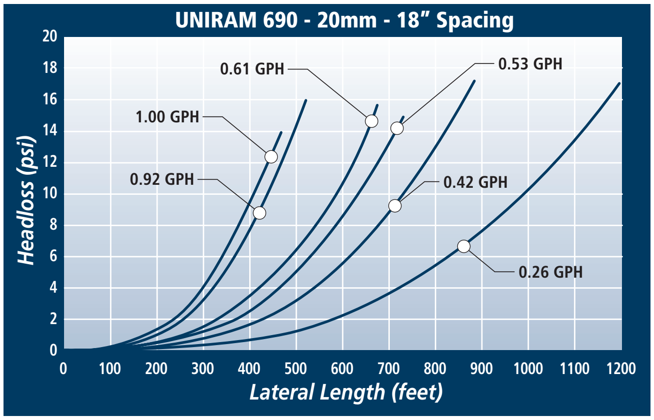
Line End Pressure* *(10 psi)*
\+ Pressure Loss *(derived from charts)*
= Inlet Pressure

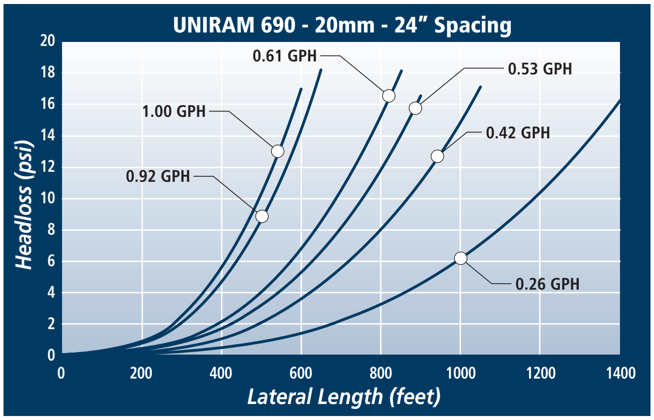
**Minimum pressure at lateral length end = 10 psi.*

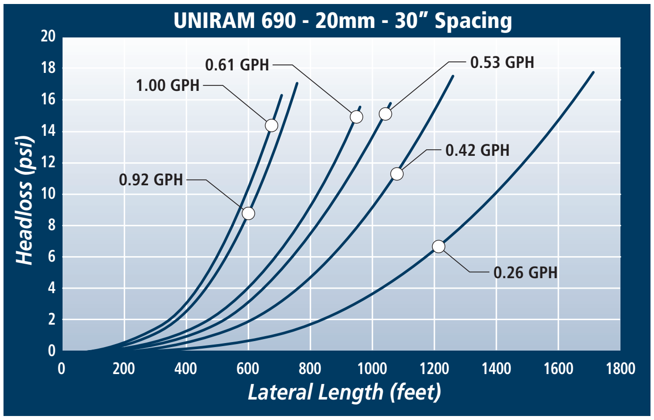
Example:

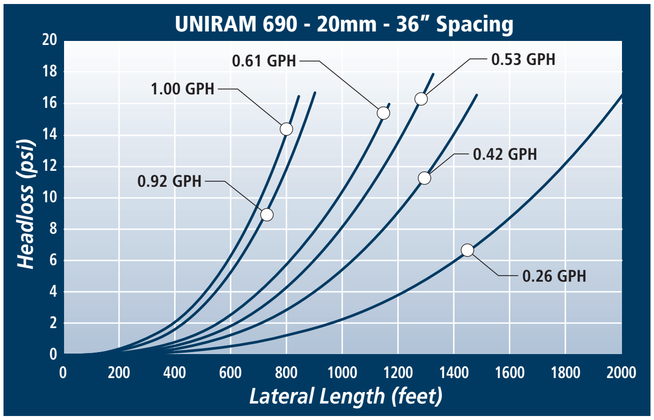
UniRam .620”		**10 psi** *(end pressure)*
575’ Run	+	**11 psi** *(from graph)*
0.42 GPH Flow Rate	=	**21 psi**
18” Spacing		

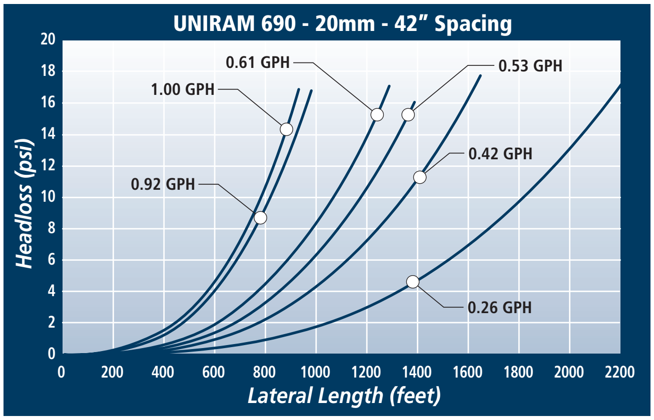
UniRam .690” (20mm, 48 mil) Headloss and Lateral Length

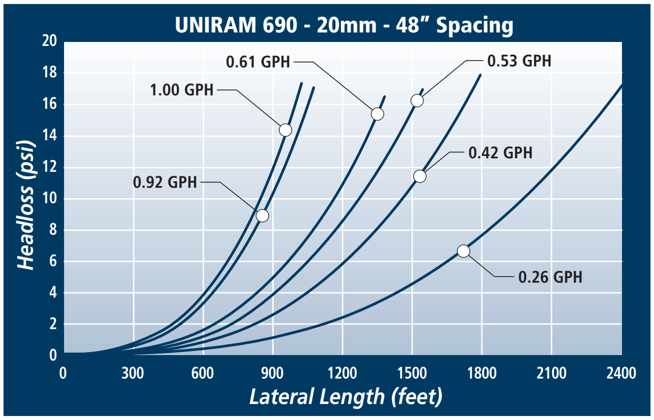


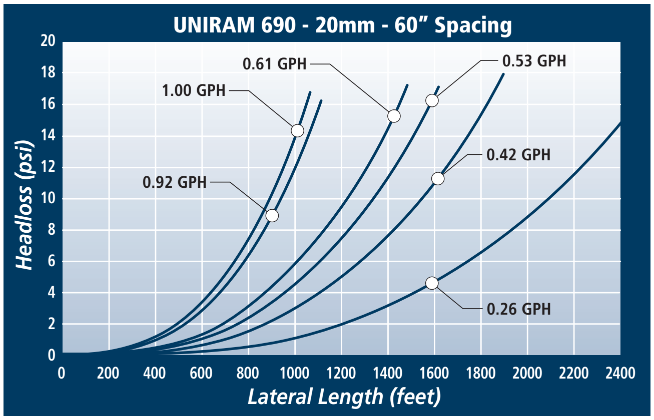












EQUATION TO CALCULATE LATERAL LENGTH INLET PRESSURE

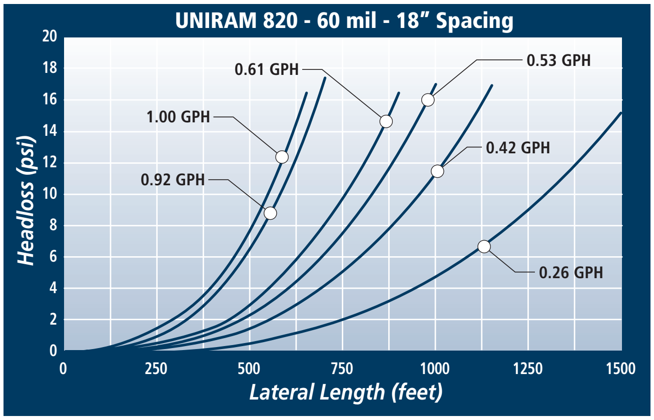
Line End Pressure* *(10 psi)*
+ **Pressure Loss** *(derived from charts)*
= **Inlet Pressure**

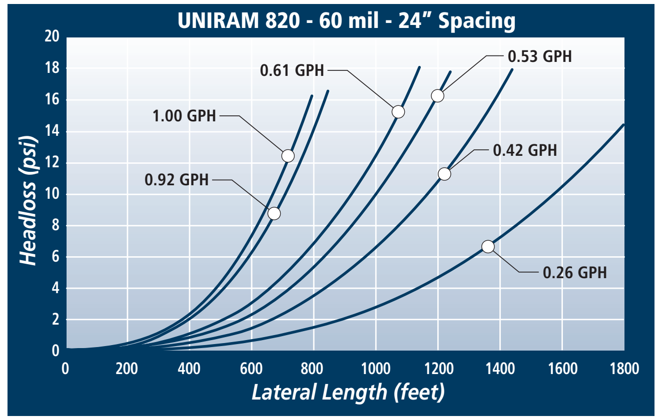
**Minimum pressure at lateral length end = 10 psi.*

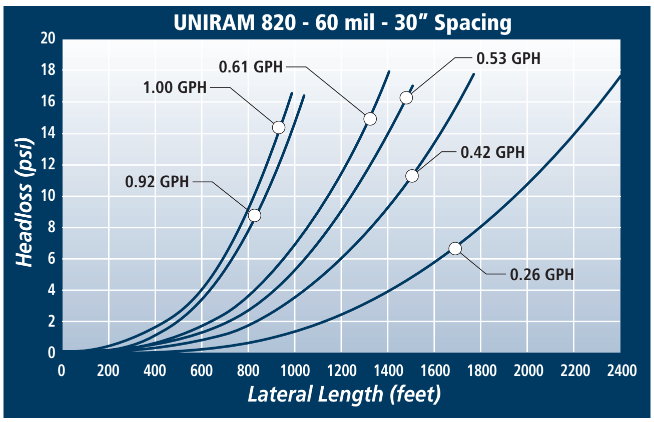
Example:

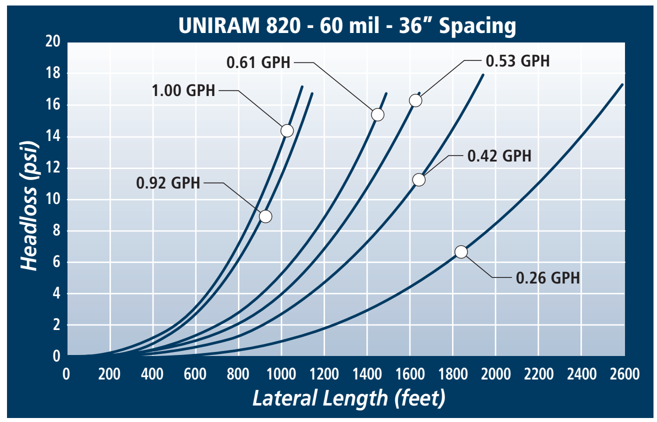
UniRam .690”	**10 psi** *(end pressure)*
750’ Run	+ **11 psi** *(from graph)*
0.42 GPH Flow Rate	= **21 psi**
18” Spacing	

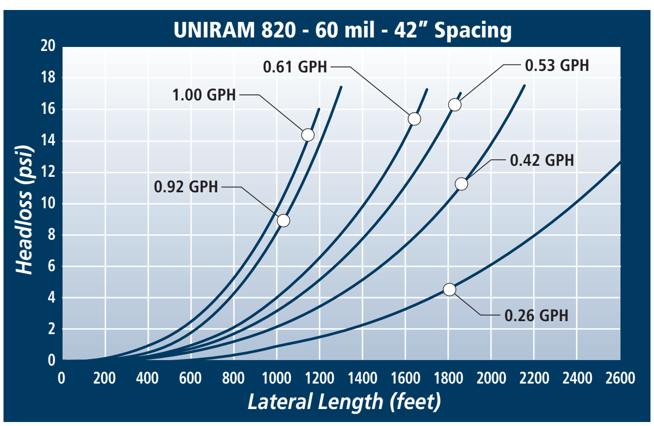
UniRam .820" (60 mil) Headloss and Lateral Length

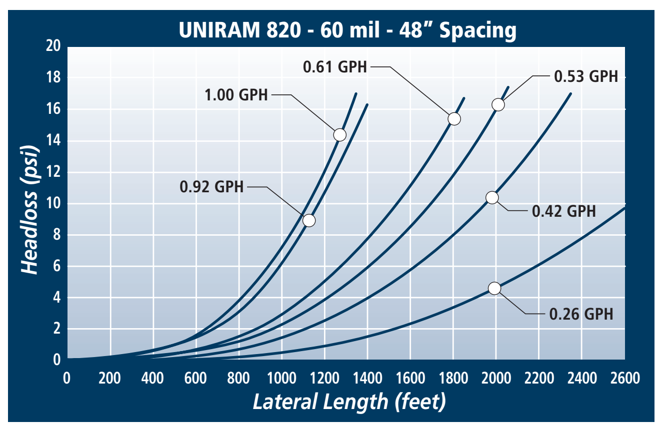


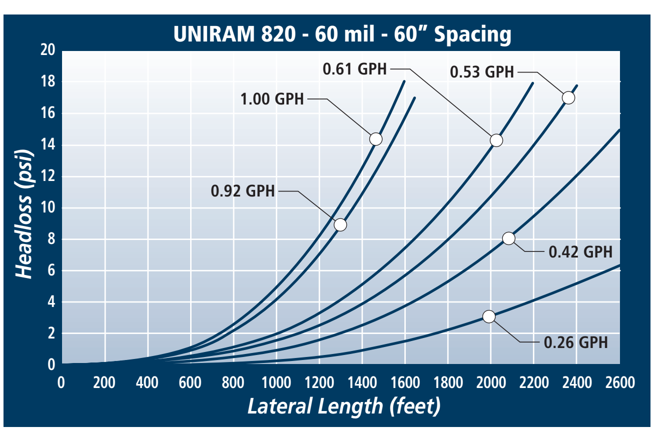












Example:

UniRam .820"	**10 psi** *(end pressure)*
980' Run	+ **11 psi** *(from graph)*
0.42 GPH Flow Rate	= **21 psi**
18" Spacing	

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CDS-John Blue Series 2000 E-Z Meter Pumps
Parts & Instruction Manual

$10.00

CDS-JOHN BLUE COMPANY

DIVISION OF ADVANCED SYSTEMS TECHNOLOGY, INC.

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Table of Contents

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THE ORIGINAL INTENT OF THIS PRODUCT DOES NOT INCLUDE USE WHERE THE MAXIMUM ALLOWED SPEED, PRESSURE, OR TEMPERATURE IS EXCEEDED, AND IT DOES NOT INCLUDE APPLICATIONS UTILIZING FLUIDS THAT ARE NOT COMPATIBLE WITH THE PRODUCT'S COMPONENT MATERIALS. DO NOT USE THIS PRODUCT WITH FLAMMABLE OR COMBUSTIBLE FLUIDS SUCH AS GASOLINE, KEROSENE, DIESEL, ETC…, AND DO NOT USE IN EXPLOSIVE ATMOSPHERES. FAILURE TO FOLLOW THIS NOTICE MAY RESULT IN SERIOUS INJURY AND/OR PROPERTY DAMAGE AND WILL VOID THE PRODUCT WARRANTY. IF IN DOUBT ABOUT YOUR APPLICATION, CONTACT YOUR STOCKING DEALER OR THE CDS-JOHN BLUE TECHNICAL STAFF AT 1-800-253-2583

Note to the Owner

Please study this manual carefully. It will assist you in the care, installation and operation of your CDS-John Blue Pump. Familiarize yourself with all parts and adjustments before attempting to operate or service your pumps. Enter your serial number and date of purchase in the space provided for future reference. This information will be required for ordering replacement parts or servicing your pump.

CDS-John Blue ENGINEERING DEPARTMENT CONSTANTLY IMPROVES ITS PRODUCTS. WE RESERVE THE RIGHT TO MAKE DESIGN AND SPECIFICATION CHANGES WITHOUT NOTICE.

SERIAL NUMBER:________________________ **DATE OF PURCHASE:________**

Safety Precautions

- Safety equipment such as gloves, goggles, etc. should be worn at all times while performing any repairs, adjustments, or maintenance to the pumping system.
- Never work on a pump that is in operation, always turn the pump off before working on it.
- Always keep loose clothing away from a pump in operation.
- A careful operator is the best insurance against an accident.
- Only trained and responsible people should operate equipment.
- Check all valves, filters, hose clamps, etc. for tightness and soundness before admitting chemicals to system. Also check again at regular intervals.
- Replace hoses when worn, cracked or if leaking.

Important Instructions

In an effort to prevent damage during the shipping process, the following items have been left uninstalled and will need to be installed by the end user before operating the pump. Reference the parts diagram on page 11 for corresponding numbers.

On all pump models, the inlet fittings (Item #24) and outlet fitting (Item #31) will need to be installed into the valves and tightened prior to use. The fittings are packaged in the bag with your instruction/operator's manual.

On all duplex model pumps, the safety covers *must* be installed before turning on the pump.

To install the safety shields:

Remove the two 1/4-20 x 3/8" slotted pan head screws located on the base plate (Item #1) just below the crank arm (Item #5). Align the two holes in the safety cover base (Item #9) with these screw holes and reinstall and tighten the pan head screws.

Align the tab on the bottom of the safety cover (Item #8) with the rectangular slot in the safety cover base (Item #9). Rotate the top of the cover away from the gearbox (Item #3) to engage the safety cover tab into the rectangular slot and then pivot the safety cover towards the gearbox sliding the two u-shaped slots in the top of the safety cover under the two 5/16" hex head bolts in the top of the gearbox. Tighten the two 5/16" hex head bolts to secure the safety cover in place.

Repeat the process for the other side.

Your CDS-John Blue E-Z Meter Irrigation Unit is now ready to use. If you have further questions or need technical assistance, please call our factory at **1-800-253-2583.**

Installation Instructions

Materials to be Pumped

The pump is for liquid, not solid or granular materials. Flammable or combustible liquids can not be used with this pump. Material with particles so small as to pass through the 80-mesh strainer should not be of concern, although if left in the pump they could crystallize and can cause the pump to malfunction.

Always pump materials that are compatible with the pump. The pump is made with various materials such as polypropylene, 316 stainless steel and Aflas seals. Materials being pumped must be compatible with these components.

Do not mix materials unless you know the results.   It is important to understand that mixing of liquids, such as adding a pesticide to a fertilizer may cause a chemical reaction. The resultant product may not be compatible and may harm the pump.

Do not mix materials unless you know what will result. CDS-John Blue Company can not be responsible for problems caused by mixing liquids.

Mounting and Pump Placement

The pump should be located below or even with the bottom level of the liquid to be pumped. This will ensure that the pump does not lose prime. ***The pump should never be allowed to run dry.***

Electrical Powered Pumps

When wiring electrical motors always **use a licensed or qualified electrician.** Both the single-phase and three-phase electric motors must be properly wired. The single-phase may be wired as either 110 or 220 volts. The three-phase may be wired as either 220 or 440 volts. On each electric motor is a wiring diagram. Make sure the power and phase match your power and have a licensed and qualified electrician install your pump. **An electrical ground must be installed. For problems with electrical motors, see the local dealer listed for the manufacturer of the motor supplied.**

Gasoline Powered Pumps

The gasoline-powered pumps are shipped without motor oil in the engine.**You must add motor oil to the gasoline engine.** The pump is designed to operate at 43 strokes per minute and must not be exceeded. The engine should run at 2150 RPM. This corresponds to 43 revolutions of the black crank arm or 43 strokes of the pump per minute. Verify this by counting the revolutions or pump strokes in 60 seconds.

Photo A

Belt Drive Pumps

Following are the instructions for mounting the belt drive pump to the well head, see photo A.

1. Bolt the two adjuster arms (1" x 12" flat steel) to base of the irrigation pump gear driving using the 5/8" bolts and washers.
2. Lay the 4" x 20" mounting plate across the adjuster arms making sure the slots intersect.
3. Take the 1/2" bolts and place them through the slots and loosely tighten the nuts so that all parts still move freely.
4. Slide the injection pump base under the three clamps on the 4" x 20" mounting plate.
5. Align the pulley on the injection pump's gearbox with the shaft to be used to turn it.
6. Position the mounting bracket so adequate tension is placed on the belt.
7. Tighten all mounting parts.
8. Using the variable pulley, adjust the pump to 43 strokes per minute.
9. Make sure the pump runs smoothly.

Plumbing

To make your own hose kit, the following materials are needed:

- 80 mesh Poly or 316 SS filter
- Ball valve
- 1/2" ID high pressure hose
- Male hose adapter fittings – 316 SS or Poly
- Pipe dope or Teflon tape
- Chemical injection fitting – local regulations s hould be followed. See your local CDS-John Blue Dealer.

The pumps are rated for 150-psi system pressure. A chemical injection fitting with a built-in spring-loaded check valve must be used at the point of injection. Refer to local codes for minimum cracking pressure required, but in no case should it be less than 10 psi. It is important that all joints are sealed properly with pipe compound or Teflon tape. Carbon steel, brass or aluminum fittings may cause pump damage as the metal may deteriorate and enter the pump. The system must have proper back flow devices and the point of injection must be downstream from these devices. Water sources may be contaminated when backflow devices are not properly installed or the injection point is not downstream. Check local codes.

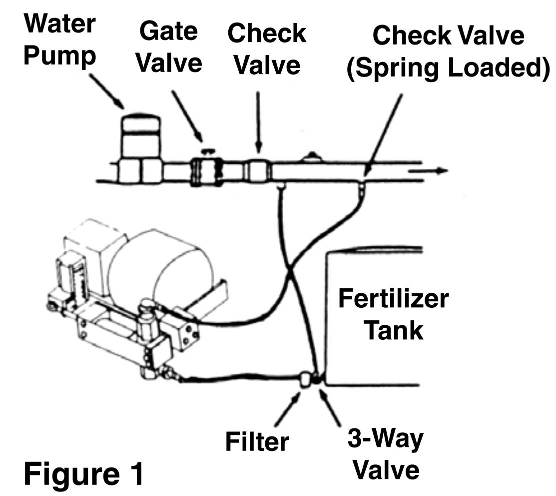


Figure 1

Figure 1 shows the basic configuration of the pump, tank and the point of injection. A filter is absolutely necessary in the inlet line. The three-way ball valve makes flushing the pump easy and convenient. A high-pressure hose with a minimum of 150 psi working pressure or higher, depending on application pressure is required. Hose lines should be kept as short as possible. Remember, check valves that are made from injection molded plastics should be supported when pushing the hose onto the fittings.

Maintenance

Priming the Pump

The CDS-John Blue Pump must be primed and will not operate with air in the hose, filter or pump. To prime the pump set it to full stroke, do not pump against pressure, and run the pump until the air is out of the system. The discharge of the pump initially should be into a bucket or back to the supply tank or other proper container until priming is complete. This may take several minutes. Liquid should gravity feed to the pump from the supply tank. The pump will lift product but this should not be relied upon to prime the pump. To avoid liquid products from gravity feeding through the pump into the irrigation line a properly functioning check valve must be installed at the point of injection. Check local codes. Once the pump has evacuated all of the air from the system, the proper discharge rate can be set.

Pump Usage

The pump should **always** be operated with the safety shield in place. As long as liquid remains at the suction side of the pump, it is not necessary to prime the pump again as detailed above. Due to the large number of hard to handle liquid products on the market today, it is difficult to establish absolute guidelines as to the frequency and method of flushing the pump. It is important that the products being pumped are compatible with the materials used in the pump, 316 stainless steel, polypropylene and Aflas. The pumped products must be free of granular or crystallized materials. If the liquid material does become crystallized or granular, it may decrease the life of the pump's seals.

Pump Storage

During periods when the pump is not in use the following steps are recommended to prevent early pump failure.

- Never store a dirty pump with chemicals still in it. **It is important to completely flush the pump when it is to be stored or not used for extended periods of time.**
- Do not store the pump filled with oil or diesel fuel.

Trouble Shooting Guide

The following trouble shooting guide is designed to assist you in fixing simple problems during the life of your CDS-John Blue E-Z Meter Injection Pumps. Please read the complete set of problems and suggested solutions as many problems overlap.

Problem: Not Pumping

No fertilizer to the pump. Check the following when fertilizer does not reach the inlet fitting on the pump:

- PUMP HEIGHT CORRECT? The pump should gravity feed to the inlet side of the pump.
- ALL VALVES OPEN? The valves should all be open to allow flow to the pump. The valves should also be sized large enough so that viscosity and temperature do not alter their flow.
- FILTER CLOGGED? The filter should be clean and large enough to allow unrestricted flow to the pump.
- ALL JOINTS TIGHT? The fittings, pipe joints and filter bowl are connections that possibly may have air leaks and should be tighten.

Air locking – the pump does not clear air out of its lines. The pump is self-priming and should clear itself after five minutes of all air in the lines. If not, check the following:

- STROKE LENGTH (Volume Setting)? When the pump is dry, it must be set to the maximum volume setting to ensure that all air is removed from the lines. To do this, set the pump to maximum setting and continue to run until air is removed from the pump.
- VALVES OPEN AND SIZED CORRECTLY? Check valves are on both the inlet and the discharge lines. If there is no place for the air to discharge to, then it will remain in the pumping lines and cylinder area of the pump.
- PUMP PRIMED? Physically prime the pump. There may be dirt or particles in the fluid that has caused a check valve not to seal properly. Many times the material will wash itself out with the action of the pump once it is primed. If a three-way ball valve has been installed for flushing the pump, this can now be turned to water and used to force water into the pump, which will flush it out. Without the valve, a separate water line may be attached to a water source to force water into the pump while the pump is running. After you force feed the pump, reconnect to fertilizer and prime the pump.

Oscillating Fertilizer. Fertilizer is going back and forth in the pump and not being pumped into the water system.

- CHECK VALVES CLEAN? Dirt or particles lodging on the sealing surfaces of the check valves can cause oscillating. The check valves should be washed out using the flushing method in “Pump Primed?” section above. If this does not solve the problem, the check valves can be removed, inspected and cleaned. To clean and inspect the check valves, first remove the rod end bearing and the front stainless steel plate by unscrewing the four 5/16 18-bolts. The check valves can then be unscrewed from the mounting block. Clean and inspect all the parts including the valve body where the balls sit and seal. Replace worn parts and reassemble. Be sure to use pipe compound or Teflon tape on all threads except the joints that hold the check valves together inside the pivot mounting block. Make sure the arrows showing the direction of the flow is correct when putting the check valves back into the manifold.

Problem: Not working against back pressure.

Pump functions normally until water pressure is increased, at which point volume decreases.

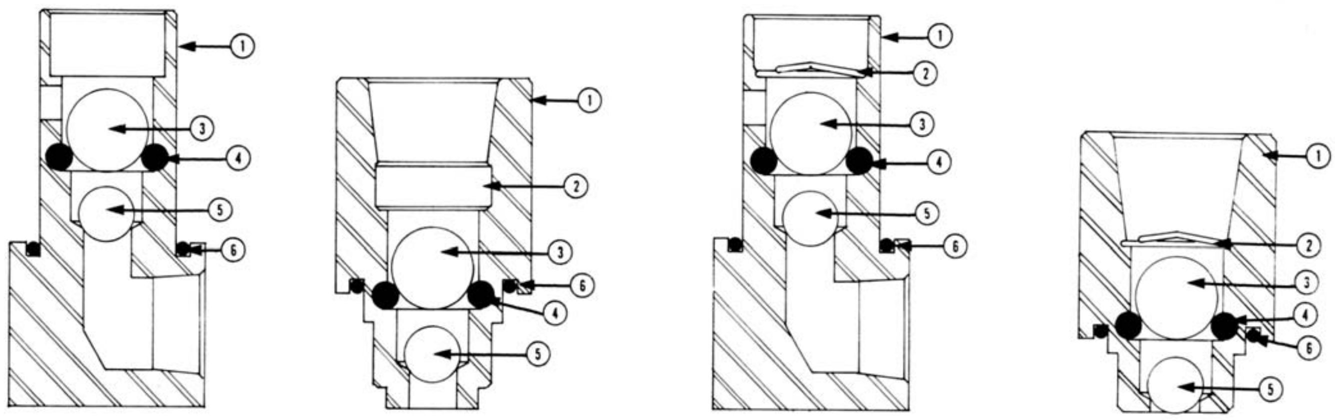
- CHECK VALVES CLEAN? See “Check Valves Clean” section above.
- VALVES IN SYSTEM/INLINE CHECK VALVES RESTRICTED? It may not be the water pressure that is causing the problem but rather increased pressure caused by closed or too small size hose or valves which restrict the pump’s flow. The size of the hose and valves should be twice that of the amount being pumped since the pump is only discharging half the time. A long hose will act as a collector to absorb some discharge thus making a prolonged discharge time as the hose expands and contracts. The inlet hose is more important then the discharge hose as an undersized hose can starve a pump.

Problem: Incorrect volume or fluctuating volume

Small variables in volume may occur because of viscosity, hoses used or head pressure. Variances should not be large enough to cause application problems. If there are significant volume differences, check the volume.

- OSCILLATING? Instead of putting a full stroke down stream, the pump is actually either pumping part back up the suction line or receiving some of the discharge back on the suction stroke. Be sure the liquid has not crystallized. See “Oscillating Fertilizer under Problem: Not Pumping” section.
- AIR LEAKS? There is a chance that the intake stroke is taking in air as well as material to be pumped. Air can enter through any loose connections or fittings including the filter bowl. Fittings should be installed with pipe compound or Teflon tape. Use non-corrosion fittings, either 316 SS or polypropylene. The filter should be checked and cleaned, being careful to reinstall the gasket properly.
- FLOW RESTRICTION? Make sure the pump receives an unrestricted flow of liquid. Make sure the material has not crystallized causing a blockage.
- ROD END BEARING? The rod end bearing will eventually wear to the point where the stroke length is effected. If this happens replace the bearing.
- FILTER CLEAN? The filter and its element should be checked to make sure it is clean and operate properly.

CDS-John Blue Series 2000 Check Valves



56-0026
Inlet Plastic

56-0027
Outlet Plastic

56-0021
Inlet
316 Stainless Steel

56-0022
Outlet
316 Stainless Steel

Parts List

Item #	Description	Plastic Inlet	Plastic Outlet	316 SS Inlet	316 SS Outlet
	Complete Check Valve	56-0026	56-0027	56-0021	56-0022
1	Body	56-0028	56-0029	56-0024	56-0025
2	Retainer Plastic	N/A	56-0030	N/A	N/A
2	Retainer Spring	N/A	N/A	56-0023	56-0023
3	Large Ball	56-9017	56-9017	56-9017	56-9017
4	O-Ring Seal	56-9031	56-9031	56-9031	56-9031
5	Small Ball	56-9007	56-9007	56-9007	56-9007
6	Check Valve Set	56-9052	56-9052	56-9052	56-9052

Designs and specifications change from time to time, CDS-John Blue Company reserves the right to alter or upgrade equipment as necessary. Always make sure you have the most current parts list before ordering replacement parts.

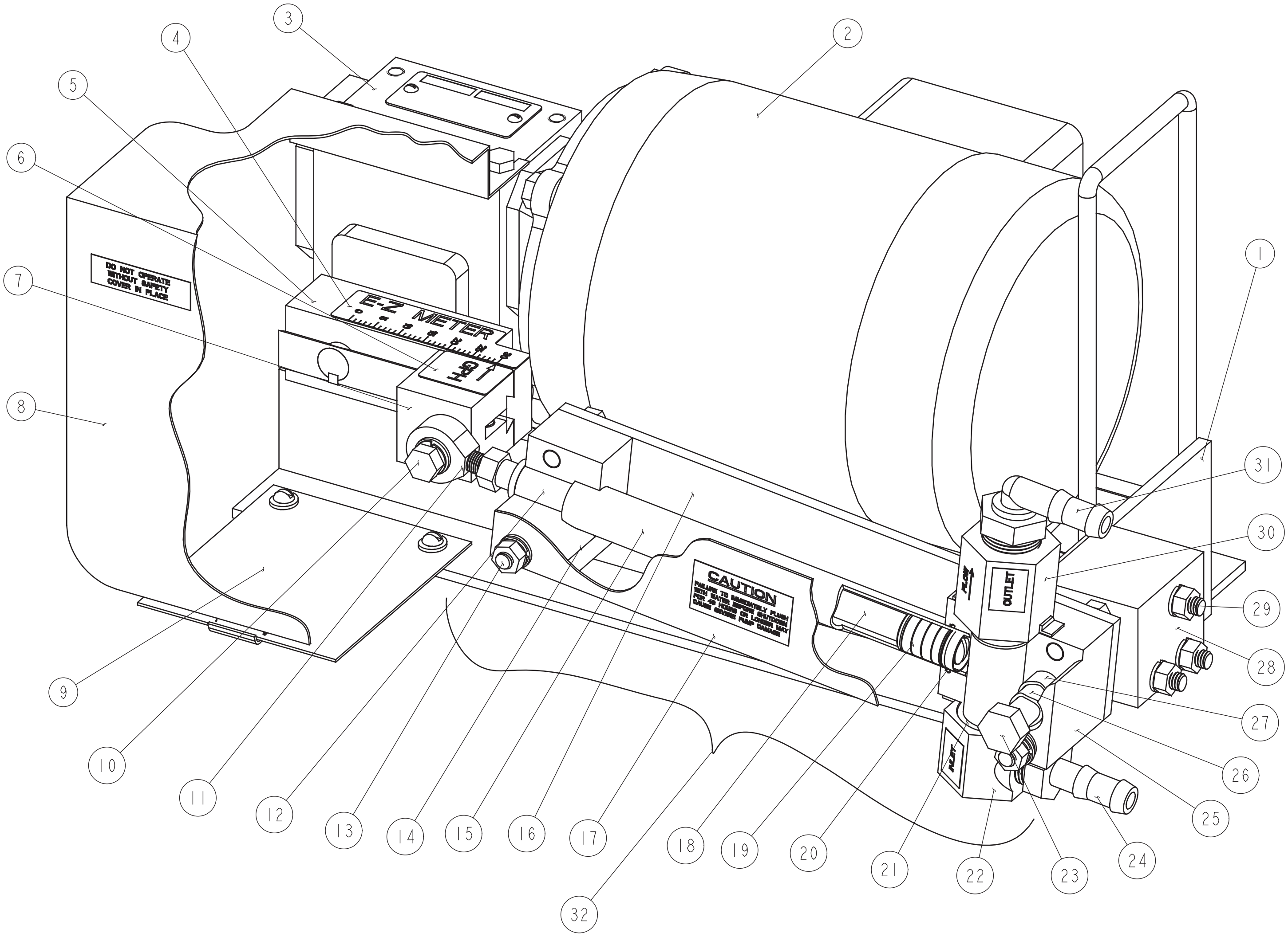
Parts List

Item #	Description		5-30 GPH	10-100 GPH
1 *	Base Plate	Electric Motor & Belt Drive	52-3001	
		Gasoline Engine	52-5001	
2	Electric Motor	3 Phase - 1/2 Hp	114902-01	
		1 Phase - 1/2 Hp	53-9004	
3 *	Gear Box	Electric Motor	53-9001	
		Belt and Gas Engine	53-9003	
4	Calibration Scale		50-3001	50-1001
5 *	Crank Arm - Less Calibration Scale		50-0002	
6	Calibration Arrow		50-0001	
7	Crank Arm Adjuster - Less Arrow		50-0004	50-0004
8 *	Safety Cover		51-0001	
9 *	Safety Cover Base		51-0002	
10	Crank Bolt, Lock & Flat Washer Hardware		54-0069	54-0069
11	Rod End Bearing		54-9001	54-9001
12	Cylinder Rod Bushing	Stainless Cylinder	54-0031	54-0031
		Teflon Cylinder	54-0031	54-0031
13	Cylinder Mounting Block Hardware	Bolt	54-9009	
		Lock Washer	54-9005	
		Nut	S-3566-2	
14	Cylinder Mount Block w/ Bushing	Stainless Cylinder	54-0023	54-0016
		Teflon Cylinder	54-0023	54-0016
15	Cylinder Tube	Stainless Cylinder	54-0021	54-0020
		Teflon Cylinder	54-0021-S	54-0020-S
16	Cylinder Mounting Plate		54-0063	
17	Front Plate		54-0068	
18	Cylinder Piston Rod		54-0001	54-0001
19	Piston Cup Assembly		54-2001-A	54-3001-A
20	O'ring - Cylinder Seal	Stainless Cylinder	54-9012	54-9011
		Teflon Cylinder	54-9012	54-9011
21	O'ring - Valve Seal		56-9031	
22	Inlet Valve	Stainless Steel	56-0021	
	Includes O'ring # 21	Plastic	56-0026	
23	Pivot Bolt		55-9001	
24	Inlet Fitting		56-9020	
25	Cylinder Pivot Block	Stainless Cylinder	54-0058	54-0059
	w/ Bushing # 27 & O'ring # 20	Teflon Cylinder	54-0058	54-0059
26	Pivot Bushing		54-0033	
27	Roller Bushing		09-0007	
28	Pivot Mounting Block		55-0003	
29	Pivot Mount Block Hardware	Bolt	54-9009	
		Lock Washer	S-3554	
		Nut	S-3566-2	
30	Outlet valve	Stainless Steel	56-0022	
	Includes O'ring # 21	Plastic	56-0027	
31	Outlet Fitting		56-9053	
32	Cylinder Assy. Without Ck Valve	Stainless Cylinder	54-2100	54-3100
	Items # 11 thru 20 & 25	Teflon Cylinder	54-2100-1	54-3100-1
	Cylinder Assy. w/ Plastic Ck Valve	Stainless Cylinder	54-2110	54-3110
	Items # 11-22, 24-25, & 30-31	Teflon Cylinder	54-2110-1	54-3110-1
Not Shown	Gas Engine Special Components	Gas Engine - 4 Hp	53-9013	
	Req' Gas Base and Gearbox	Coupling for Gas Engine	53-9017	
Not Shown	Belt Drive Special Components	Belt Drive Mounting Bracket	52-1000	
	Req' Belt Base and Gearbox	Adjustable Pulley - Belt Drive	53-9018	
Not Shown	Duplex Conversion Kit **	Stainless Cylinder	50520	50530
	Items # 4 thru 31	Teflon Cylinder	50520-1	50530-1
*	Pump serial # > 222500 reflects change to standard on items # 1, 3, 5, 8, 9			
**	Duplex Conversion Kits can only be used on serial # > 222500.			

CDS - John Blue technical support is available at:

www.cds-johnblue.com or 1-800-253-2583 Mon - Fri, 8am - 5 pm cst

E-Z METER SERIES 2000 PUMPS



LIMITED WARRANTY

THIS WARRANTY IS IN LIEU OF ALL OTHER WRITTEN OR EXPRESS WARRANTIES AND REPRESENTATIONS. ANY IMPLIED WARRANTIES INCLUDING MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE ARE EXPRESSLY LIMITED TO THIS WRITTEN WARRANTY. CDS-JOHN BLUE COMPANY SHALL NOT BE LIABLE FOR CONSEQUENTIAL DAMAGES.

Use of this product for any purpose other than its original intent, abuse of the product, and/or any modification to the original product is strictly prohibited by the manufacturer, CDS-John Blue Company. Any modification to the product should be approved by CDS-John Blue Company prior to use. CDS-John Blue Company will deny Warranty claims and liability in any situation involving misuse, abuse or modification.

Each new machine or component manufactured by CDS-John Blue Company through original buyer is warranted by CDS-John Blue Company to buyer and to any party or parties to whom buyer may resell, lease or lend the equipment to be free from defects in material and workmanship under normal use and service. This obligation of CDS-John Blue Company under this warranty is limited to the repair or replacement of defective parts or correction of improper workmanship of any parts of such equipment which shall within one year from the date of CDS-John Blue's original delivery thereof, be returned to CDS-John Blue's factory, transportation charges prepaid and which CDS-John Blue Company shall determine to its satisfaction upon examination thereof to have been thus defective. When it is impractical to return the defective parts of such equipment to CDS-John Blue's factory, then CDS-John Blue shall have no liability for the labor cost involved in repairing or replacing any such parts and shall be liable solely for supplying the material necessary to replace or repair the defective parts, provided that prior thereto CDS-John Blue Company shall have determined to its satisfaction that any such parts are thus defective.

This warranty shall not apply to any equipment which shall have been repaired or altered outside CDS-John Blue's factory in any way so as to affect its durability, nor which has been subjected to misuse, abuse, negligence or accident, or operated in any manner other than in accordance with operating instructions provided by CDS-John Blue Company. This warranty does not extend to repairs made necessary by the use of inferior or unsuitable parts or accessories, or parts or accessories not recommended by CDS-John Blue Company.

CDS-John Blue Company makes no warranties in respect to parts, accessories or components not manufactured by CDS-John Blue Company, same ordinarily being warranted separately by their respective manufacturers.

DIVISION OF ADVANCED SYSTEMS TECHNOLOGIES HUNTSVILLE, AL (256) 721-9090

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2" & 3" Disc-Kleen Filter Batteries

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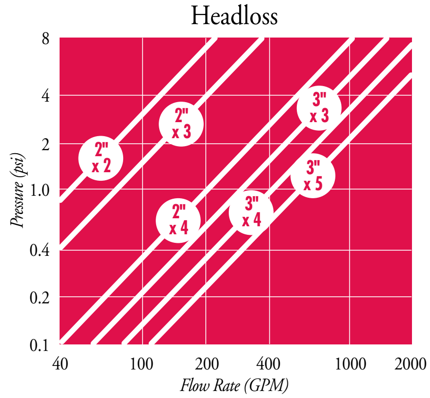
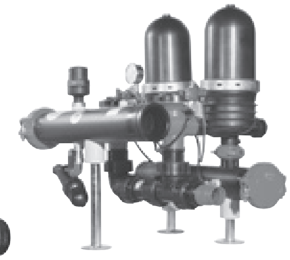
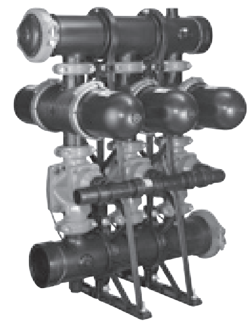
Headloss





2" Disc-Kleen Filter Battery



3" Disc-Kleen Filter Battery

Product Advantages

- Quick Installation – factory assembled and tested, arriving on a pallet ready for hook-up and immediate operation.
- Less Maintenance – molded spine, chemically resistant and performs reliable backflush. Manual cleaning is practically eliminated.
- Filtration Grade Versatility – filtration discs can be changed quickly and easily from 40 mesh up to 200 mesh.
- Optimizes Irrigation – less backflush time means more uniform application of water in the field.
- System Flexibility – each Disc-Kleen Battery is capable of handling a wide operational flow range.
- Lasts Longer – manufactured from engineered synthetics to resist rust and corrosion from chemicals and weather.
- Standard with installed polypropylene drain manifold.

Filtration Process

As dirty water travels through a Disc-Kleen Filter, debris is captured along the walls and in the grooves of the channels in the filter element. During the backflush cycle, the valve changes position, the pressure in the outlet manifold loosens the discs automatically. A specially designed nozzle system inside the filter stack then sprays pressurized water against the loosened discs, spinning them clean quickly and efficiently. After backflushing, the stack of discs automatically compress to resume filtration.

PART NUMBERS

Part Number	Size	No. of Filters	Manifold Size
26ASKPP2A2-XXX	2"	2	4" GR
26ASKPP2A3-XXX	2"	3	4" GR
26ASKPP2A4-XXX	2"	4	4" GR
26ASKPP3A3-XXX	3"	3	6" GR
26ASKPP3A4-XXX	3"	4	6" GR
26ASKPP3A5-XXX	3"	5	6" GR

Substitute XXX for proper mesh size. GR = Grooved.

Applications

- For surface water containing algae and other organic materials such as reservoirs, canals, rivers and waste water applications.
- For well water containing light sand (<3 ppm) and other contaminants.

Specifications

Includes installed drain manifold
Inlet and outlet connections: Grooved
Backflush valve flush port: 2" NIPT
Maximum operating pressure: 140 psi
Minimum backflush pressure required: 40 psi downstream of filter during backflush
Minimum backflush flow per spine: 35 GPM
Minimum pH: 5
Mesh sizes and color: 40 - Blue
80 - Yellow
120 - Red
140 - Black
200 - Brown
280 - Green

Materials

Manifold:	Polypropylene
Filter Body:	Glass Reinforced Polyamide
Spine:	Polypropylene
O-Rings and Seals:	EPDM

NETAFIM™

NETAFIM USA
5470 E. Home Ave. • Fresno, CA 93727
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2" & 3" Disc-Kleen Filter Batteries Technical Information

2" x 2 FILTERS
WATER SOURCE MAXIMUM FLOW RATE (GPM)

Mesh size	80	120	140	200
Good	180	160	145	120
Average	160	150	130	90
Poor	130	120	90	65
Very Poor	80	70	60	40

2" x 3 FILTERS
WATER SOURCE MAXIMUM FLOW RATE (GPM)

Mesh size	80	120	140	200
Good	270	240	220	180
Average	240	225	195	135
Poor	195	180	135	95
Very Poor	120	105	90	60

2" x 4 FILTERS
WATER SOURCE MAXIMUM FLOW RATE (GPM)

Mesh size	80	120	140	200
Good	360	320	290	240
Average	320	300	260	180
Poor	260	240	180	130
Very Poor	160	140	120	80

3" x 3 FILTERS
WATER SOURCE MAXIMUM FLOW RATE (GPM)

Mesh size	80	120	140	200
Good	540	480	435	340
Average	480	450	390	270
Poor	380	340	270	180
Very Poor	240	210	180	120

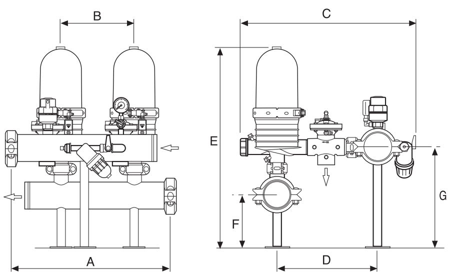
3" x 4 FILTERS
WATER SOURCE MAXIMUM FLOW RATE (GPM)

Mesh size	80	120	140	200
Good	720	640	580	480
Average	640	600	500	360
Poor	500	450	340	260
Very Poor	320	280	240	160

3" x 5 FILTERS
WATER SOURCE MAXIMUM FLOW RATE (GPM)

Mesh size	80	120	140	200
Good	800	800	725	600
Average	800	750	600	450
Poor	650	525	400	300
Very Poor	400	350	300	200

IMPORTANT NOTE: We have categorized water quality as a guideline for filtration requirements. Be aware all water quality categories shown above are general. Your water quality may vary. If your water contains more than two parts per million of sand, a sand separator is recommended. If in doubt, consult an authorized Netafim USA dealer.

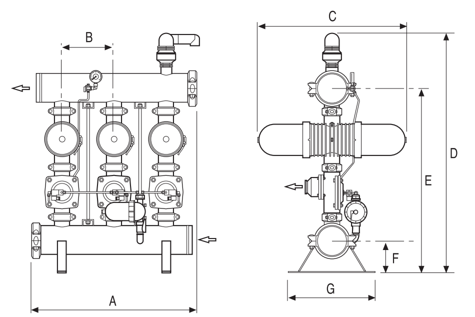


2" DISC-KLEEN FILTER BATTERY DIMENSIONS

	A	B	C	D	E	F	G	Weight	Amount of Backflush Water
2 FILTERS	27 3/4"	11 13/16"	25 7/8"	16 5/16"	30 29/32"	7 9/32"	14 3/4"	174 lbs	18 gallons
3 FILTERS	39 9/16"	11 13/16"	26 1/32"	16 5/16"	30 29/32"	7 9/32"	14 3/4"	220 lbs	27 gallons
4 FILTERS	51 3/8"	11 13/16"	26 1/32"	16 5/16"	30 29/32"	7 9/32"	14 3/4"	266 lbs	36 gallons

3" DISC-KLEEN FILTER BATTERY DIMENSIONS

	A	B	C	D	E	F	G	Weight	Amount of Backflush Water
3 FILTERS	37 1/4"	9 3/4"	34 1/16"	50 3/4"	41 1/4"	7 1/4"	22"	352 lbs	54 gallons
4 FILTERS	47 1/4"	9 3/4"	34 1/16"	50 3/4"	41 1/4"	7 1/4"	22"	407 lbs	72 gallons
5 FILTERS	59 1/16"	9 3/4"	34 1/16"	50 3/4"	41 1/4"	7 1/4"	22"	467 lbs	90 gallons



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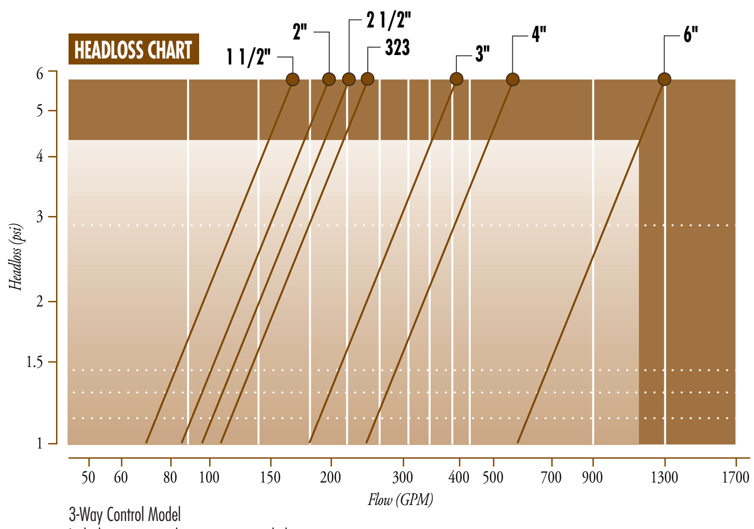
Nylon and PVC Valves

Nylon Valve

PVC Valve

6" PVC Valve

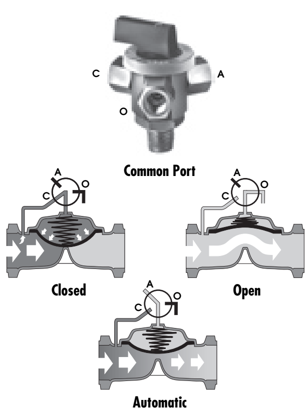
High Resistance to Fertilizers and Chemicals



3-Way Control Model
Light brown area indicates recommended operating range.

Product Advantages

- Manufactured with threaded and socket (slip) connections.
- Requires one diaphragm type with low operating pressure.
- Superb hydraulic performance.
- High resistance to corrosive water containing fertilizers and chemicals.
- Pipes can be cemented into PVC valves.
- Simple to install with slip or threaded PVC connections.
- Simple design - diaphragm is the only moving component, no shaft, seals or bearings are located within the water passage way.



Netafim USA's Basic Valve can be operated manually through the use of a 3-way selector. Selector options are:

Closed (C): Upstream pressure or pressure from an external source is applied to the control chamber. Initiated by the spring, the diaphragm is pressed down to close the valve drip-tight.

Open (O): Relieving the water or air pressure to the atmosphere from the control chamber causes the valve to open.

Automatic (A): The automatic port of the 3-way selector is connected to a solenoid, hydraulic relay or pilot, which controls the valve. The common port of the 3-way selector connects the control chamber to either A, O or C, depending on the direction the selector is pointed.

Cv $H\ (psi) = \left(\frac{Q\ (GPM)}{Cv}\right)^2$

SIZES	1"	1 1/2"	2"	323	3"	4"	6"
	18	66	83	103	175	250	554

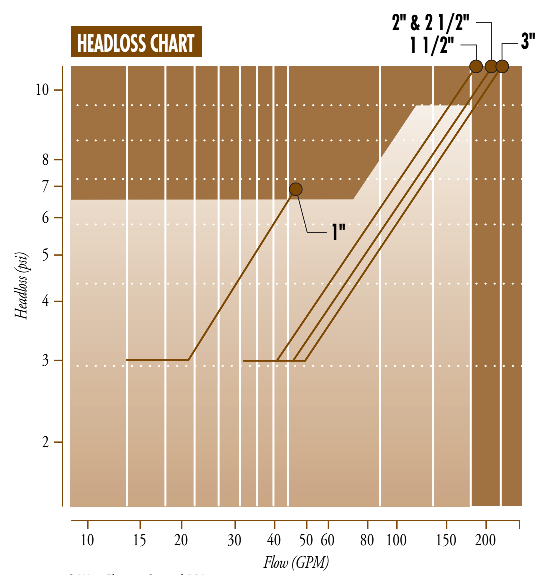
Applications

- Ideal for water control in PVC networks.
- For use in Agricultural and Greenhouse & Nursery applications.
- Surface or Sub-surface installations.
- **Functions:** Pressure Reducing, Pressure Sustaining, Pressure Relief, Electric, Remote Control.

Specifications

Maximum water temperature: 140° at maximum pressure.

- **Operating Pressure (psi):**
  Nylon - 12 minimum, 145 maximum
  PVC - 12 minimum, 115 maximum



2-Way Electric Control PBI
Light brown area indicates recommended operating range.

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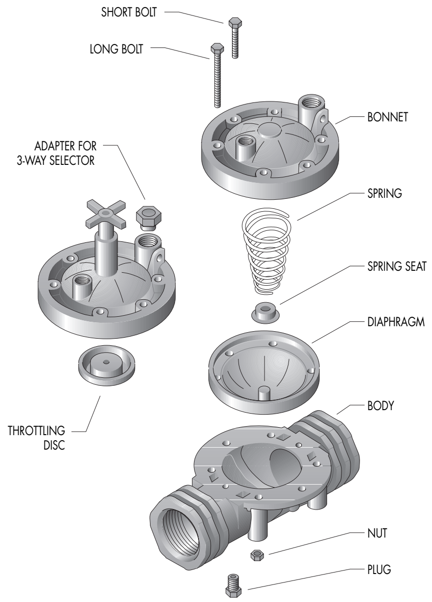
Nylon and PVC Valves Specifications



(Nylon valve shown above)

VALVE DATA

	Nylon				PVC			
	Threaded				Threaded	Slip		
Size	1"	1 1/2"	2"	323	3"	3"	4"	6"
Length (in.)	4 7/8	7 3/8	7 7/8	9 1/4	10 1/8	10 1/8	11	14
Height (in.)	2 7/8	4 3/8	4 3/8	4 3/4	7 5/8	7 5/8	8	15
Weight (lbs.)	0.4	2	2.2	3.1	9.3	9.3	9.5	20
Max. Pressure (psi)	115	140	140	140	115	115	115	150

OPTIONS

REMOTE CONTROL	Electric Hydraulic	Specify normally open or closed for main valve pressure rating and voltage. Order Catalog #61GALIT
BONNET	Standard	Nylon Valves are available with a throttling feature.
HOOK-UP	Standard	1/4" Nylon Tubing

Materials

Nuts, bolts and washers: Zinc coated steel/BS 5216
Nylon Valves only: Body, Bonnet and Seat: 30% Glass Reinforced Polyamide (GRP)
PVC: Body - uPVC
Spring: Stainless steel AISI 302
Connections: Threaded - ANSI (NPT Female)
Socket - IPS, PVC Standard
Diaphragm Materials: Standard - Natural Rubber
Special - EPDM (Ethylene Proplylene Polymer)
Special - Nitril (Butadiene Acrylonitrile)

MODELS AVAILABLE

	MATERIAL	Nylon	PVC	
	CONNECTION	Threaded	Threaded	Slip
SIZES	1"	●		
	1 1/2"	●		
	2"	●		
	323	●		
	3"		●	●
	4"			●
	6"			●

Valve Installation Tips

Threaded Valves

Use a few layers of Teflon tape or Teflon sealer compound on the adapter and tighten by hand. Use a wrench to tighten the adapter another half revolution.

Socket or "Slip" Valve with PVC Pipe

Use the same procedure as when cementing PVC pipes. Mark the pipe first, then apply glue to the socket of the valve and the PVC pipe. Insert the pipe until reaching the mark and rotate a quarter turn. Hold the joint in place until the cement hardens.

Installation Above Ground

When installing a manifold above ground the length of the manifold should be kept as short as possible, (this eliminates the need for additional support). For longer lengths a firm support under the horizontal pipes is recommended. Always install the valve with the bonnet exposed to the sun.

Diaphragm Replacement

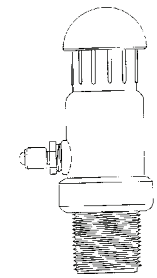
Loosen bolts, remove old diaphragm and install new diaphragm. Tighten the bolts, applying even pressure in a diagonal pattern, until the diaphragm is firmly pressed between the body and the bonnet. Do not over tighten. If leakage occurs between the bonnet and valve, tighten until leakage stops.

Underground

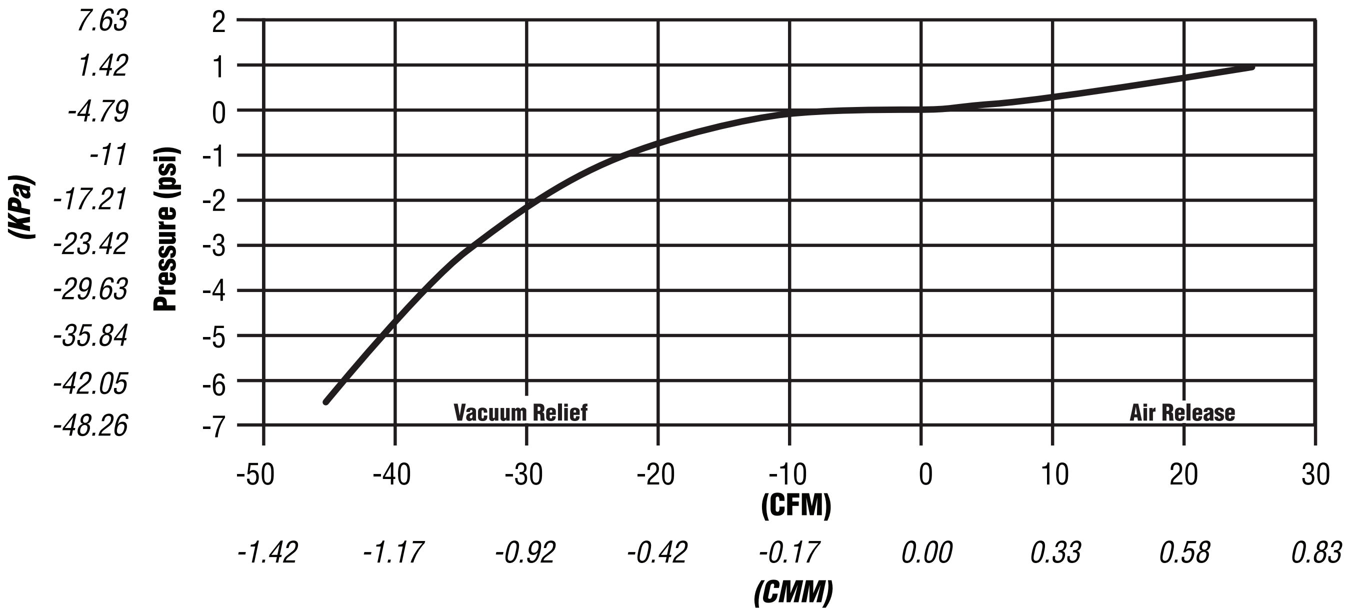
For underground installations use thrust blocks where needed, allow sufficient space and keep the area around the valve free from rough objects and stones. Cover the valve with clean soil – up to 24" is recommended for protection against heavy equipment. The controls for the valve, like the pilot, 3-way valve, should be positioned above ground. Be sure to mark the control tubing by color or number and put a protective poly or PVC tubing around the control tubing.

VBK-Series Dual Acting Air Release / Vacuum Relief Valve
VBK-1, VBKV-1

- 80 psi working pressure
- Inlet 1" NPT or BSP
- Seals at 5 psi
- Clear open diameter is 0.610"
- Optional Schrader valve to check system pressure

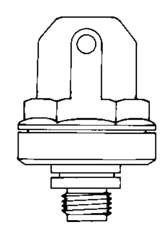


Performance Graph for the VBK-1, VBKV-1

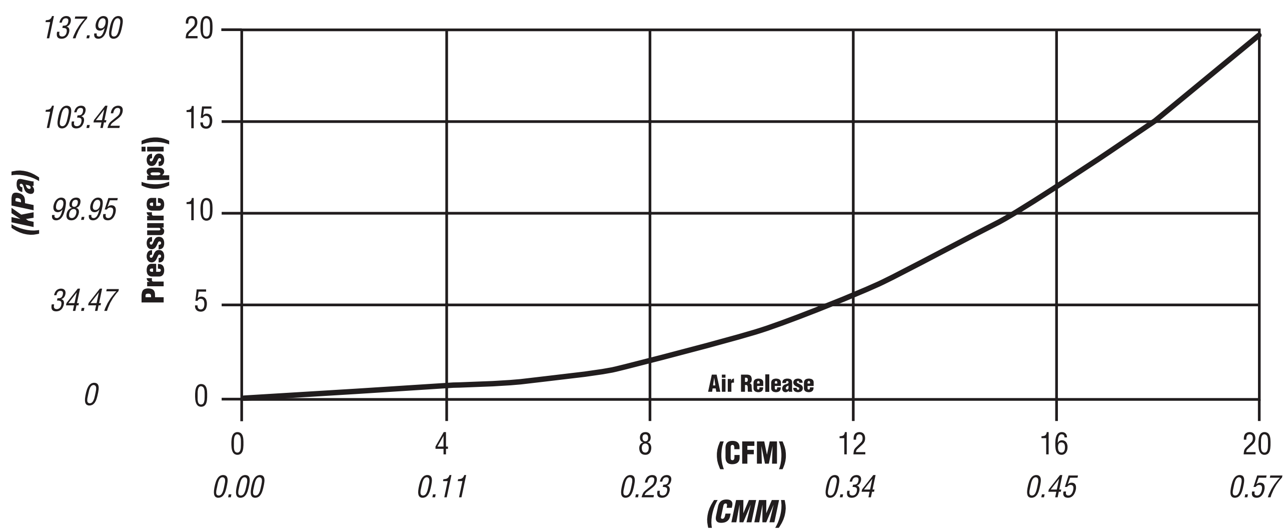


ARV-1 Continuous Air Release

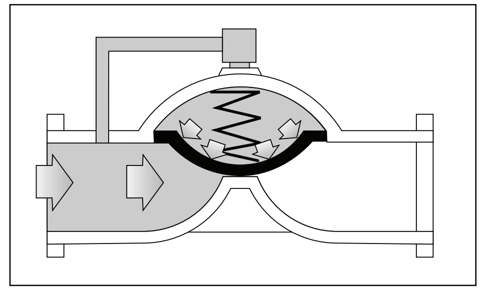
- 170 psi working pressure
- Inlet 1" NPT or BSP
- Simple design
- Easy maintenance



Performance Graph for the ARV-1



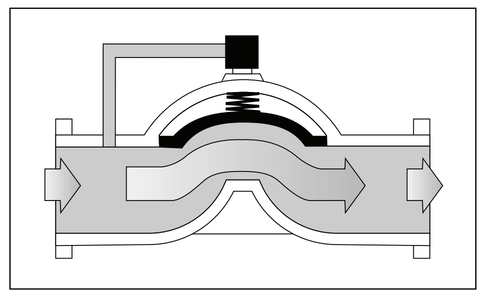
OPERATION OF BASIC VALVES



CLOSED VALVE
Upstream pressure covers twice the surface area in bonnet, valve closes

DIRECT-SEALING DIAPHRAGM

The direct-sealing diaphragm valves are operated by pipeline pressure or by air pressure (which equal to the pipeline pressure). The reinforced rubber diaphragm seals the water passage when the line pressure reaches the valve's control chamber. Relieving the pressure from the control chamber causes the valve to open.



OPEN VALVE
Opening Port releases pressure from inside bonnet.

REINFORCED RUBBER DIAPHRAGM

The valves only moving part is its diaphragm. A spring located above the diaphragm ensures "valve closure" regardless of pressure level and flow conditions.

BASIC VALVES and DEFINITIONS

HYDRAULICS

Properties of water used in practical designs

Specific weight: 0.036 lb/in^3

Kinematic viscosity: 10.76 ft^2/sec

Static Pressure: the column of water stored in a tank with relation to a relative surface, or the potential energy in a pipe line

Dynamic Pressure: the energy gradient that cause a flow of water

Flow Rate: the amount of water passing through a nozzle within a period of time

Flow in an open discharge equation:

$$Q = \frac{V \times D^2}{0.409}$$

Where: Q = gpm

V = feet/sec

D = Diameter (ID) inch

0.409 = Unit conversion factor

Valve pressure loss: the pressure differential across a valve caused by friction

Where: Q = gpm

$$\Delta P = \left(\frac{Q}{Cv}\right)^2$$

Cv = Flow factor (Flow of water (gpm) @ 1 psi loss, Temperature @ T=72˚ Farenheit

WHAT IS A CONTROL VALVE

Control (regulating) valves are semi-automatic directional devices, which control flow and/or pressure in a water supply network. The valves are pre-set to the required operating parameters, requiring minimal adjustments by the operator.

OPERATING PRESSURES FOR VALVES

The standard valves are divided into three pressure categories:

- Medium pressure models (up to 230 Psi)
- High Pressure models (up to 350 Psi)
- Plastic valves (up to 150 psi)

OPENING PRESSURES OF VALVES

Check to ensure that the Upstream Dynamic Pressure is not below the Minimal Opening Pressure of the valve, this can cause the valve not to open or to open partially. A partially open valve will cause a higher head-loss - using special low pressure diaphragms will solve this problem.

OPERATING VELOCITIES FOR VALVES

These valves may be used at very high flow velocities due to the shape of the valve body, which is almost turbulence free. The valves may be operated in the fully open position at 23-24 feet/sec. velocity without noise, shuddering or cavitation damage.

MEDIA CONTROLLED BY VALVES

The valve is very suitable for controlling slurries, untreated sewage water, water with high sand content as well as the normal types of media controlled by these types of valves. This is due to the design of the valve, which has no shaft, bearings, seals or discs in the water passage.

CONTROL MEDIA FOR VALVES

The valve can be controlled by an external source such as air or clean water in cases where the media is very dirty or abrasive.

When a very high reducing ratio is required, you may consider using:

- Two valves in sequence (inline).
- A fixed orifice within the pipe to reduce the regulation ratio of the valve to the recommended 3:1 ratio. This solution is only possible when the flow is at a constant level.

Special attention should be given to maintain the operating pressures within the specified limits.

PRESSURE LOSSES WITH VALVES

As the water passes through the valve in an almost straight line, the head-loss created by the valve is very low. Consequently, the Automatic Control Valve has a very high CV Equation factor. This allows extremely high flow velocities, in many cases a smaller valve can be used instead of a larger valve of a different model. This is not detrimental to the system and is more economical.

The head-loss on a valve fitted with a 3 Way Control System (positioning) is less than a valve fitted with a 2 Way Control System.

CAVITATION POTENTIAL WITH VALVES

The valves unique structure make them very resistant to cavitation. However, it is not recommended to exceed a 3:1 ratio of Upstream/ Downstream pressures.

When higher regulation ratios are required (up to 5:1), it is recommended to use cast bronze or non-metal (nylon/PVC) valves.

Note: Pressure Relief valves and Level Control valves whose downstream pressure is virtually zero, will create destructive cavitation levels. Therefore, the use of bronze valves or a proper orifice plate is essential for long-life of the main valve. This condition occurs in all brands of valves. Please consult Netafim USA's engineers for further information.

GENERAL INFORMATION ABOUT VALVES

In-line self-flushing filters, ensuring clog-free operation of the control devices, are a standard feature on all control valves.

Manual override (3-Way Selectors) can be added to Three Way (Positioning) valves only.

Netafim USA's broad range of specialized control valves allows us to design a solution to almost any control system, no matter how complicated. Please note, we have not included our complete line of valves in this presentation. If a control system is not here, please contact your distributor or Netafim USA's Customer Service Department. We will design a tailor made control valve for your system if one is not currently available.

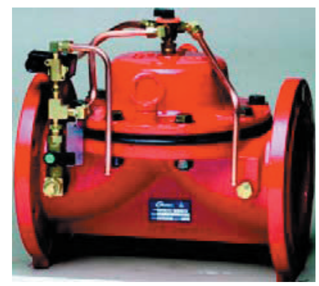
AUTOMATIC CONTROL FUNCTIONS

MANUAL ON-OFF VALVE (M)

Equipped with a 3-way manual selector valve, permits the selection of the "open" or "closed" position of the main valve.

Control Devices: 3-way valve

Available: On all 3-way controlled valves



ELECTRIC CONTROL VALVES (EL)

A 3-way solenoid valve, activated by an electric current or electric pulse, opening or closing the main valve. *"Normally closed"* position of the main valve is standard. *"Normally open"* position is optional. Electric activation can be added to most control valves on request.

Control Devices: Sizes 3/4" - 6" - Solenoid Valve
Sizes 8" - 24" - Solenoid Valve + Accelerator Relay

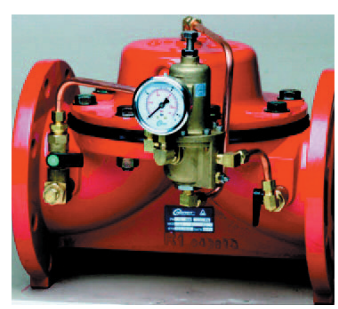
Available: On all models

PRESSURE REDUCING VALVE (PR)

The valve maintains a preset downstream pressure, regardless of upstream pressure or flow rate fluctuation. The main valve is controlled by a 3-way pilot valve (permitting full opening when downstream pressure drops below the set-point) or by a 2-way pilot valve (creating a pressure differential in any condition).

Control Devices: 29100, 29110, 31300 Pilot Valves (3-Way)
29400, 68400, 68600 Pilot Valves (2-Way)

Available: On all models



PRESSURE SUSTAINING / RELIEF VALVE (PS)

The valve maintains upstream (inlet) pressure, regardless of flow rate variations. The valve will be in the "closed" position if the inlet pressure drops below the set-point. It fully opens when upstream pressure exceeds the set-point.

Control Devices: 29110, 29200, 31300 Pilot Valves (3-Way)
68500, 68700 Pilot Valves (2-Way)

Available: On all models

HYDRAULIC REMOTE CONTROL

Principles and assembly schemes

1. GENERAL

The hydraulic remote control of “Gal” type valve is made in order to enable operating all the valves in the irrigation project from a central control point, mostly (but not necessarily) from the pump site.

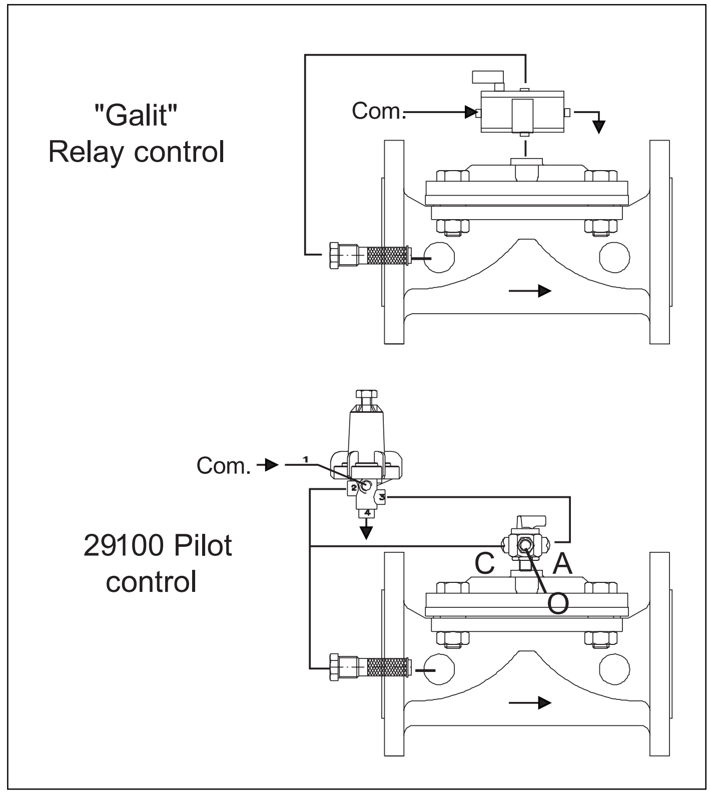
The control is executed by manual or automatic (electronic) means located in the control center, that send “open” or “close” commands to the valves.

This publication does not refer to the various aspects of control means selection but rather considers the “command” as pressure applied to or relieved from the start point of the control tube, regardless of the device used to do it.

2. REMOTE CONTROLLED VALVE

A hydraulic relay should be added to the basic hydraulic valve, in order to enable opening and closure of the valve by the local pressure. The relay is activated by increasing or decreasing the pressure in the control tube - which is done much faster than transporting all the water of the valve’s control chamber long distance to the control center, through small diameter tube.

Netafim valves use the “Galit” relays. It is equipped with manual activation device allowing local operation of the valve.



REMOTE CONTROL VALVE

3. Control Center

Manual center (see drawing #2)

The Manual Center consists of:

- 3-way selector valves
- Model SY3
- Shift (a group of valves operating simultaneously)

3-WAY VALVE

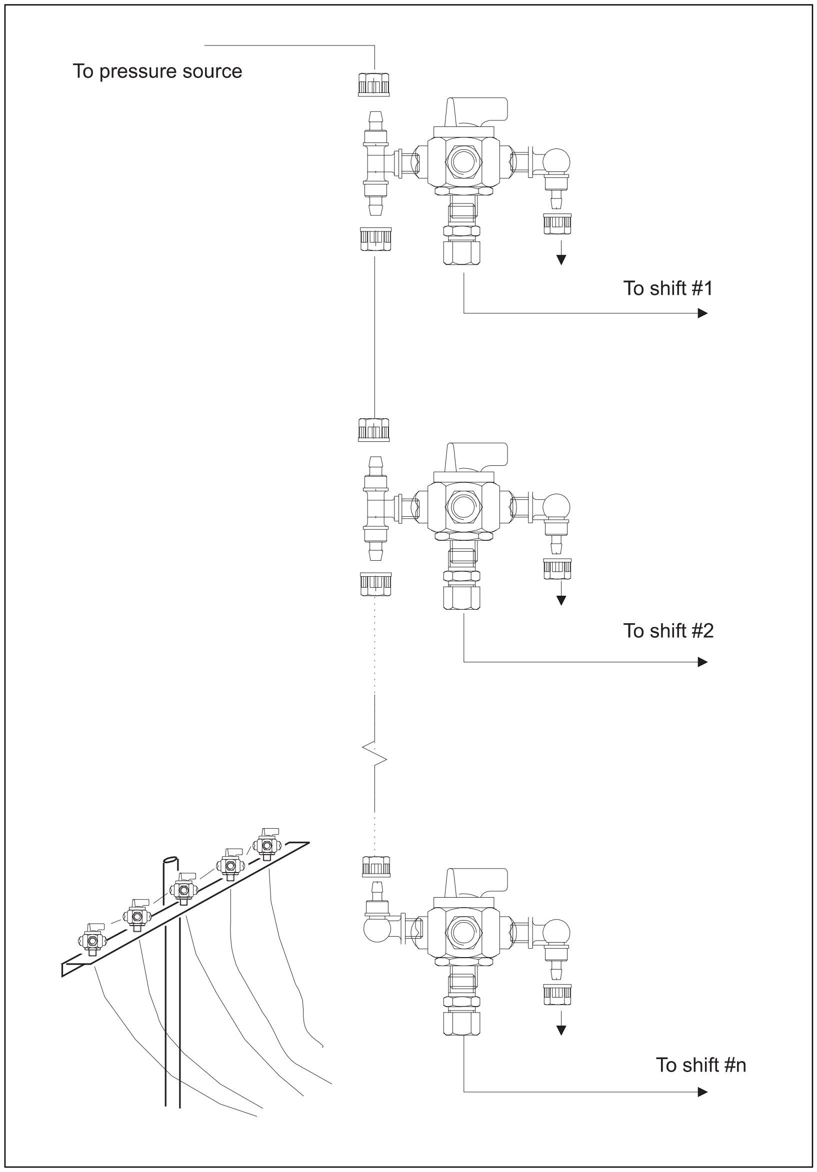
Each 3-way valve is connected, at one of its selected ports, to the main line pressure.

The common port (the bottom one) is connected to a 6mm command tube leading to the relevant group of field valves.

The knob of the 3-way valve allows selection between the pressure port and the venting port.

The third port is unused, reserved for connection of automatic control device in the future.

The 3-w selector valves should be assembled on a common bracket, each one marked clearly by its shift number.

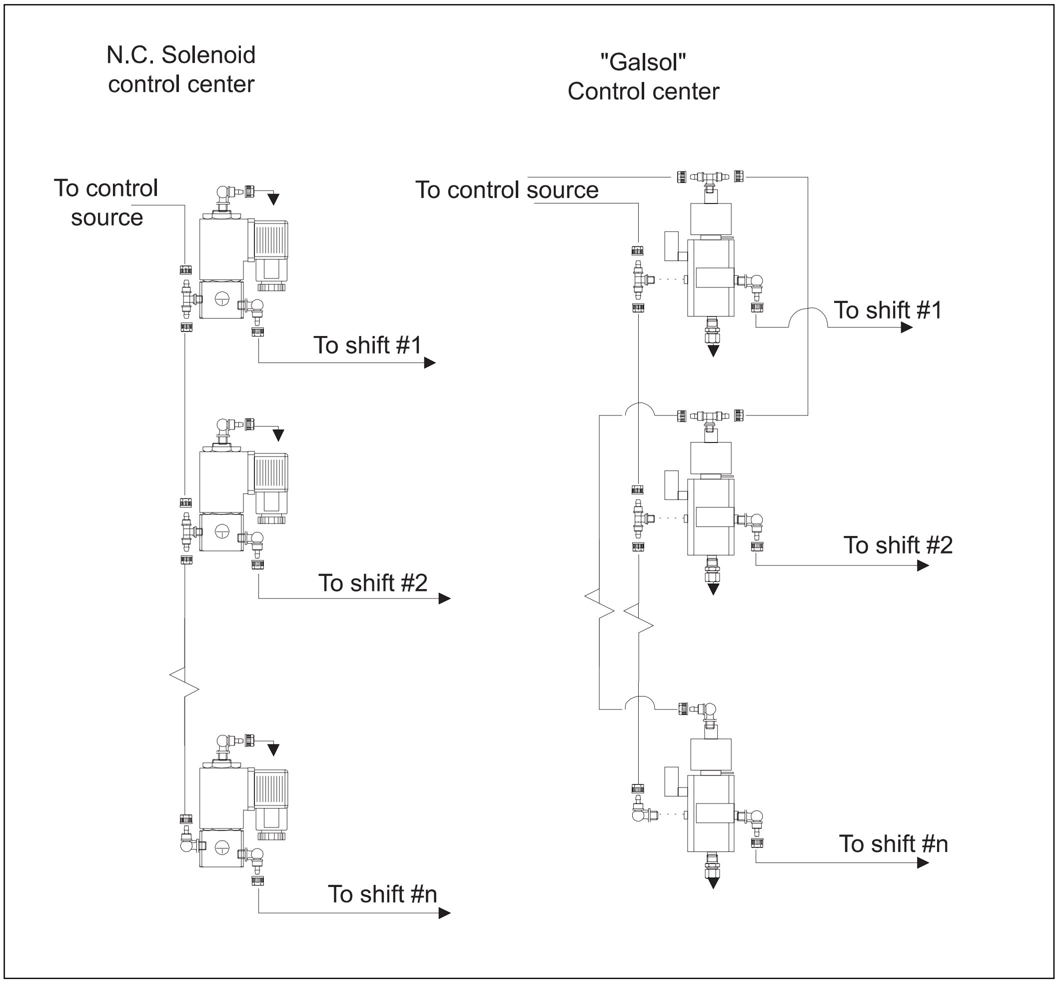


3.2 AUTOMATIC CENTER

The device selecting between pressurized control tube and relieved tube is activated by electric command.

The device can be a solenoid valve or the “Galsol” relay. The latter has larger passages than the normally used solenoids so it is less sensitive to clogging, and creates faster response of the controlled valves.

Any type of solenoid, selected for this function, must be equipped with a manual override to enable operating the system in case of electric malfunction.



4. CONNECTING FIELD VALVES TO THE CENTER

4.1 A 6mm tube should connect all valves operating simultaneously to one control device (manual or automatic). There is no advantage to larger diameter, unless the valves are located fairly near to the center, the relay is deleted so the control water volume must be transported to the valve from the center.

Using 8mm tube in relay control increases the cost unnecessarily and delays valve response.

4.2 It is recommended to connect all valves operating in the same shift and located in short distance from each other by "chain connection" as described in the drawing.

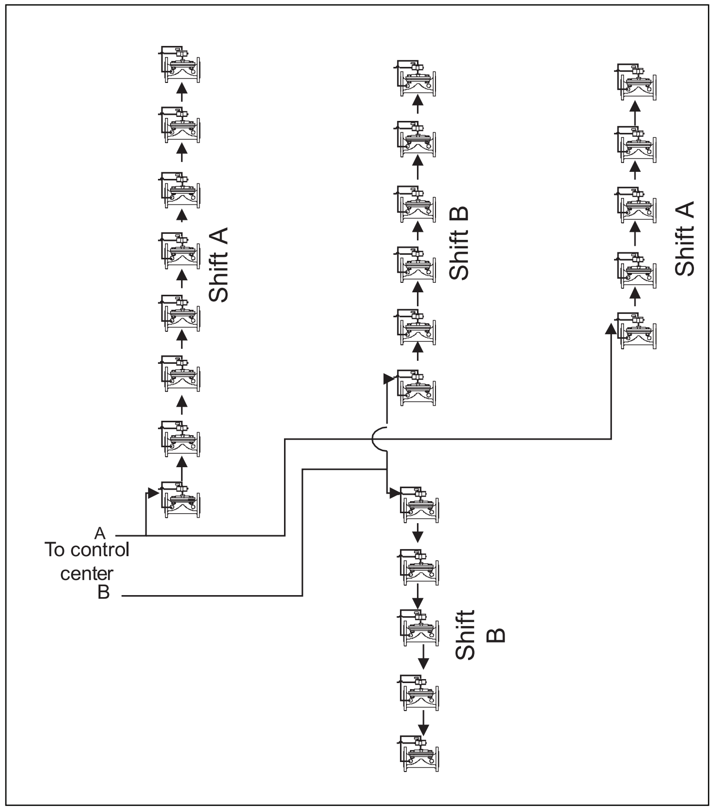
The first valve's relay is connected to the center. The command port of the valve outlet is connected to the relay of the next valve and so on.

Definition: On "open" command, first valve is open. The next one will open only when the network of the first valve has been filled and its pressure rises.

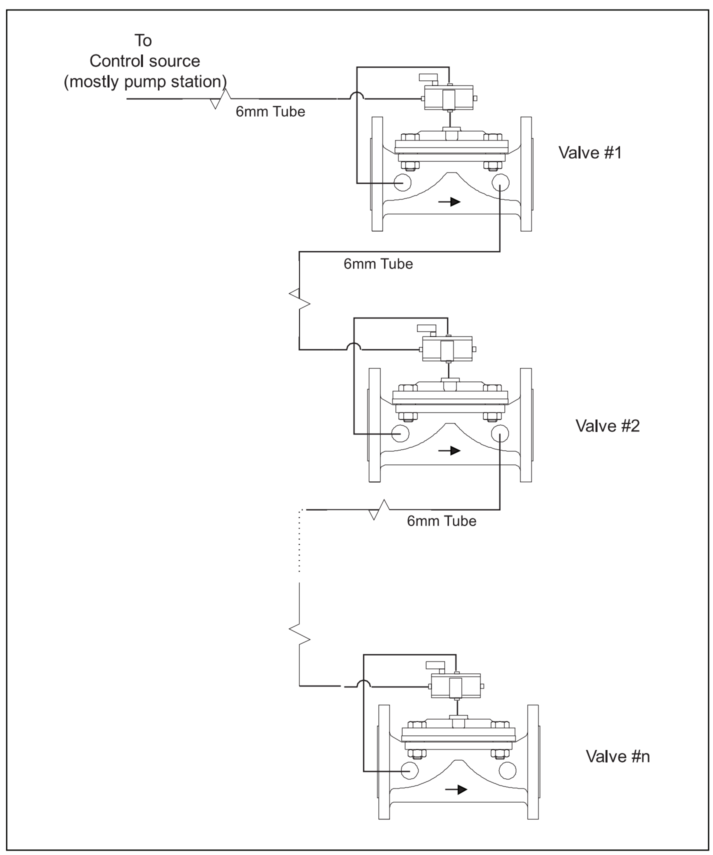
The sequence of events is reversed at "close" command - the first valve closes, then the second, etc.

This procedure prevents drop of pressure due to increased flow through the initial stage of network filling. It makes the changeover between shifts smoother, with less pressure fluctuation.

It is possible, however, to connect all the relays directly to the tube leading to the center. If this option is selected, all the valves may get the command at the same time.



CHAIN CONNECTION



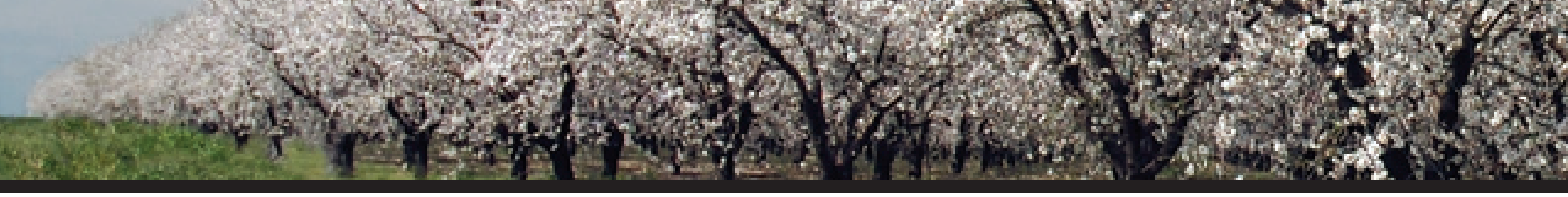
CONNECTING FIELD VALVES

NMC Pro System Manager

Maximize the Performance of Your Irrigation System from One Central Location

NETAFIM USA

DRIP/MICRO IRRIGATION PRODUCTS



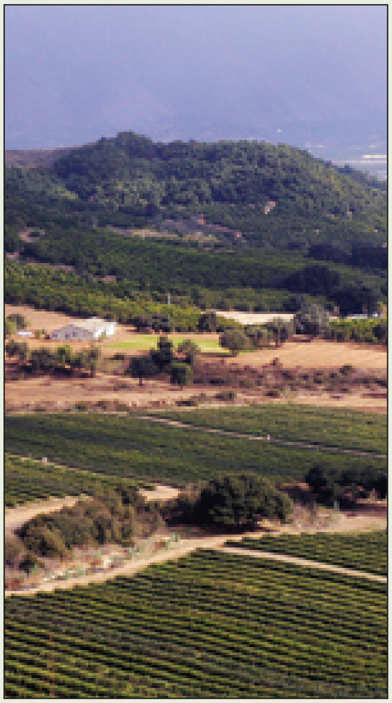
Monitor and Control from One Central Location

The NMC Pro System Manager does more than open and close irrigation valves - it integrates all of your control features in one easy-to-use unit. From one central location, you can operate, monitor and maximize the performance of your irrigation system.

It's an affordable system manager for growers with small or large operations. The flexibility and expandability of control outputs and inputs allows you to modify the system to accommodate growth. Advanced features like fertilizer and EC/pH control can be accessed if and when you want. It's truly a system that grows with your needs.

Automating with the NMC Pro System Manager allows you to maximize the return on your irrigation investment and realize the full benefits of drip/micro irrigation:

- Improved plant response through timely irrigation and fertilization
- Maximize nutrient availability (especially in sub-surface drip irrigation) by maintaining appropriate irrigation water pH
- Achieve high system uniformity through continuous treatment preventing emitter plugging
- Reduce and optimize input of water, energy, labor, chemicals and fertilizers



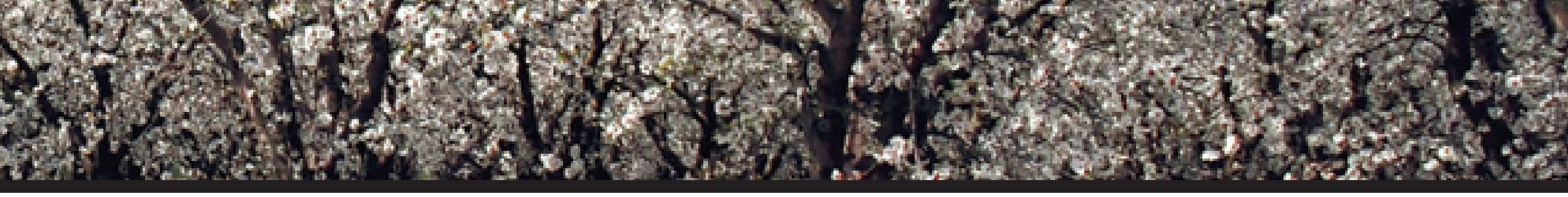
"We cut water use and costs by 30% ..."

It's been several years and Bill Steed is very satisfied with his Netafim automation products. "Netafim has the strongest automation technology", said Steed. "By using the NMC System Manager in combination with other Netafim Crop Management Technology products, we have reduced the amount of water usage, cut water costs by 30% and the crop output has stayed consistent."

The reliability of the system manager is what he needs and depends on. "It's almost bulletproof," he said. Steed uses a NMC System Manager on his blueberry crop to control the injection of organic materials, fertilizer injection and valve control. "The system allows me to control the valves in a reliable and cost effective manner. Record keeping and accessing consistent data is crucial", he said.

Steed uses his PC communication software option to frequently view logs and events. He can remotely program settings or make adjustments based on what is happening in the field. "This is a system I trust. I know if it's working or not. I'll continue to use Netafim automation for future installations - the savings in time and water make it a great investment," said Steed.

Bill Steed -
Fairfield Farms LLC, Pauma Valley, CA



The NMC Pro Does More Than Just Open and Close Valves

Netafim USA's NMC Pro System Manager is fundamental to achieving the most production with the least amount of labor. Reducing irrigation labor costs means your time can be spent on other farming activities. This system provides the control necessary to optimize irrigation efficiencies and fertilizer injection functions.

System expandability means the control system can grow based on the future needs of your operation. When combined with optional expansion cards and boxes, the NMC Pro System Manager can control up to 256 outputs and 54 inputs. Additional output cards are easy and quick to install.

In addition to opening and closing valves, the NMC Pro System Manager also includes these software programs:

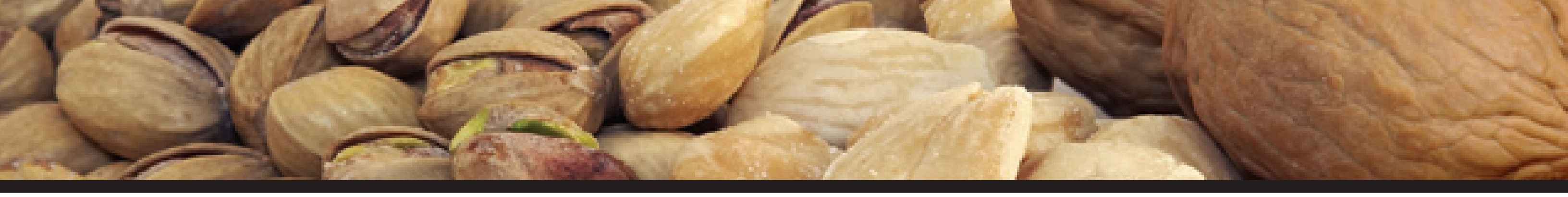
- **Irrigation Programs**
  Repeat and modify your irrigation schedules as needed - with up to 60 valve run time programs using time or volume based scheduling.
- **Irrigation Trigger Programs**
  Up to 15 external condition programs with programmable parameters for triggering irrigation events.
- **Pump Control Programs**
  Control multiple pumps, delay start or shut down times between pumps and valves.
- **Filter Flushing Programs**
  Schedules backflush programs eliminating the need for additional external backflush controllers.
- **Fertilizer and Nutrient Injection Programs**
  A range of dosing options are available - by time, quantity or proportional along with detailed alarm messages.
- **Cooling Programs**
  Programmable parameters including set points for activating cooling systems.
- **Alarm Programs**
  A range of alarms protect the system by isolating the problem and providing event details.

Features

- Up to 256 Control Outputs
- Up to 32 Digital Control Inputs
- Up to 22 Analog Control Inputs
- 15 Irrigation Programs
- 8 Dosing Channels
- Flushing up to 24 Filters
- Cooling
- Fertigation by Time, Quantity, Proportional Time or Proportional Quantity
- History of Water and Fertigation Events
- EC/pH Control
- PC Communication

Features for Greenhouse Applications:

- Misting
- Humidification



NMC Pro Features

Only Netafim Offers a Program Memory Back-up Key

All the programs of the NMC Pro are backed-up to a memory key. As an added benefit, the NMC Pro comes standard with an SD card for simple and quick software upgrades.

- Programs are secure - eliminates reprogramming to restore settings
- Gives you confidence to learn the program and make changes knowing all initial settings have been saved and can be restored
- Removable for safe storage

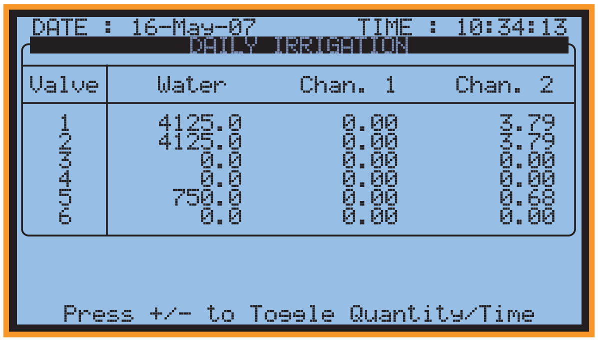
Memory Key

SD Card

Easy to Read and Program with Large Graphic LCD Display

- Simple programming with large graphic LCD display - 16 lines x 40 characters - 5″ x 2 ½″
- Displays icons, text and graphics
- Readable in direct sunlight

Simulated LCD Display Screens



Displays water meter and fertilizer injection logging.

Evaluate and Manage the System with Real-Time and Historical Records

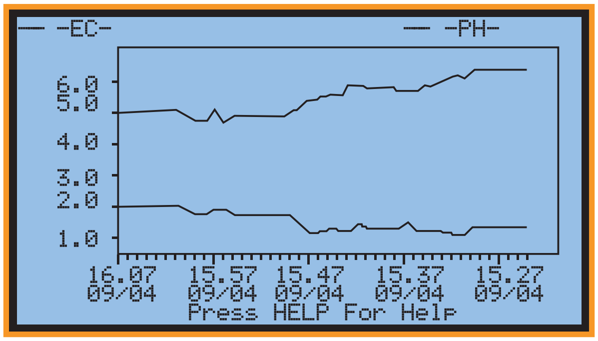
Graphical data and event logging appears on the LCD screen in graph or text formats

Logging:

- Water meter totals
- Temperature and relative humidity sensors (requires additional equipment)
- Fertilizer application totals
- Filter backflushing events
- EC/pH levels

Graphing:

- EC/pH levels



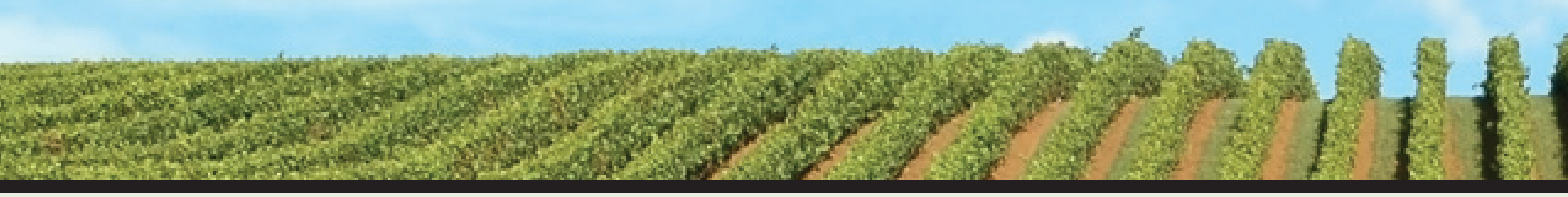
Displays EC and pH data in a graph format based on pre-programmed parameters.

Programming is Quick and Easy with a User-Friendly Keyboard

- Keys have tactile feel and are easy to read
- Hot key menu provides instant navigation
- Hot Keys are programmable for individual preferences
- Scrolling functions for quick access

Adaptable to Your Environment with a Choice of Power Sources

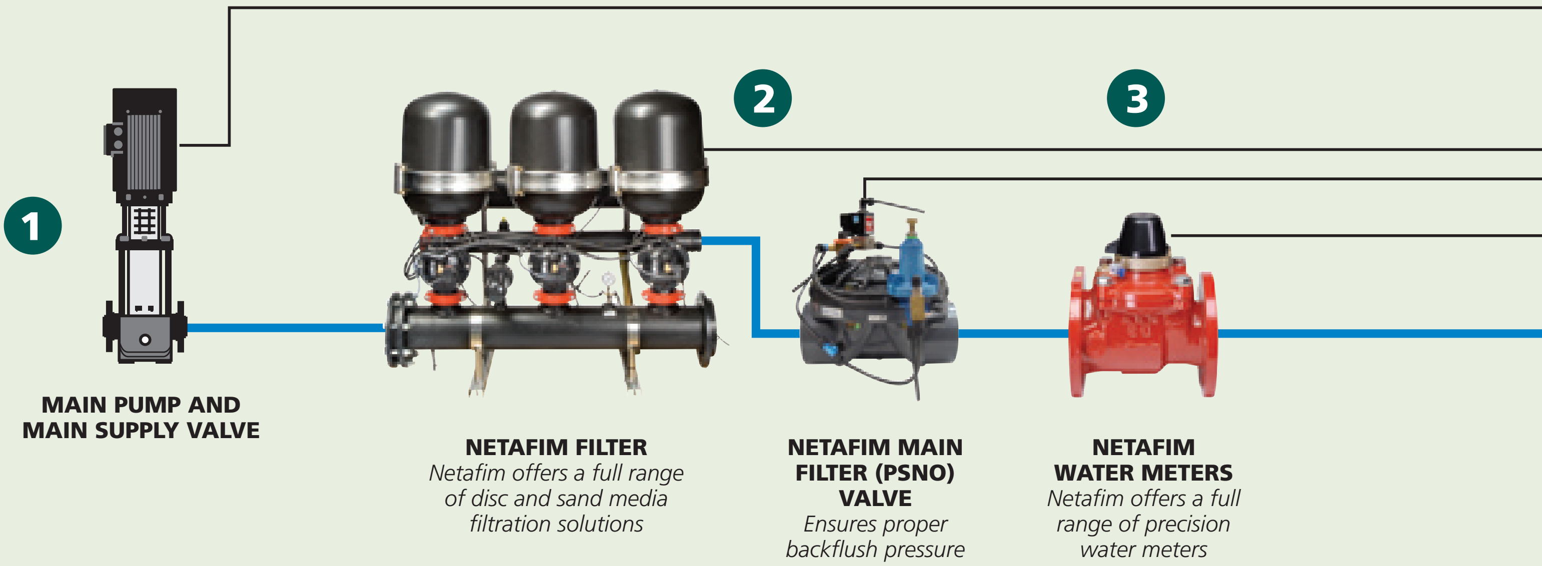
- Application with AC voltage uses the 115VAC power supply card
- Application with DC voltage uses the 12VDC power supply card
- AC power supply uses an optional 12VDC backup battery to keep the system manager on during power failure reducing the risk of lost or damaged data



NMC Pro Provides an Expandable Integrated Irrigation System Solution

As part of Netafim's integrated system approach, the NMC Pro System Manager monitors and controls Netafim quality filters, valves, and water meters maximizing the performance of the irrigation system.

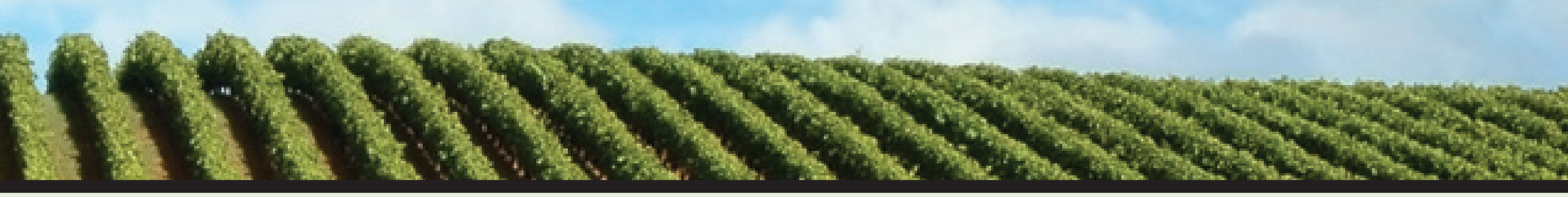
Basic irrigation and filtration functions (1,2, 3 and 6 below) can be automated with a few simple programming steps. Additional programs, chemical injection and EC/pH control are possible through the NMC Pro with the purchase of additional equipment and control kits. The NMC Pro System Manager can be used as a stand-alone unit or as a standard component within the NetaJet precision injection unit.

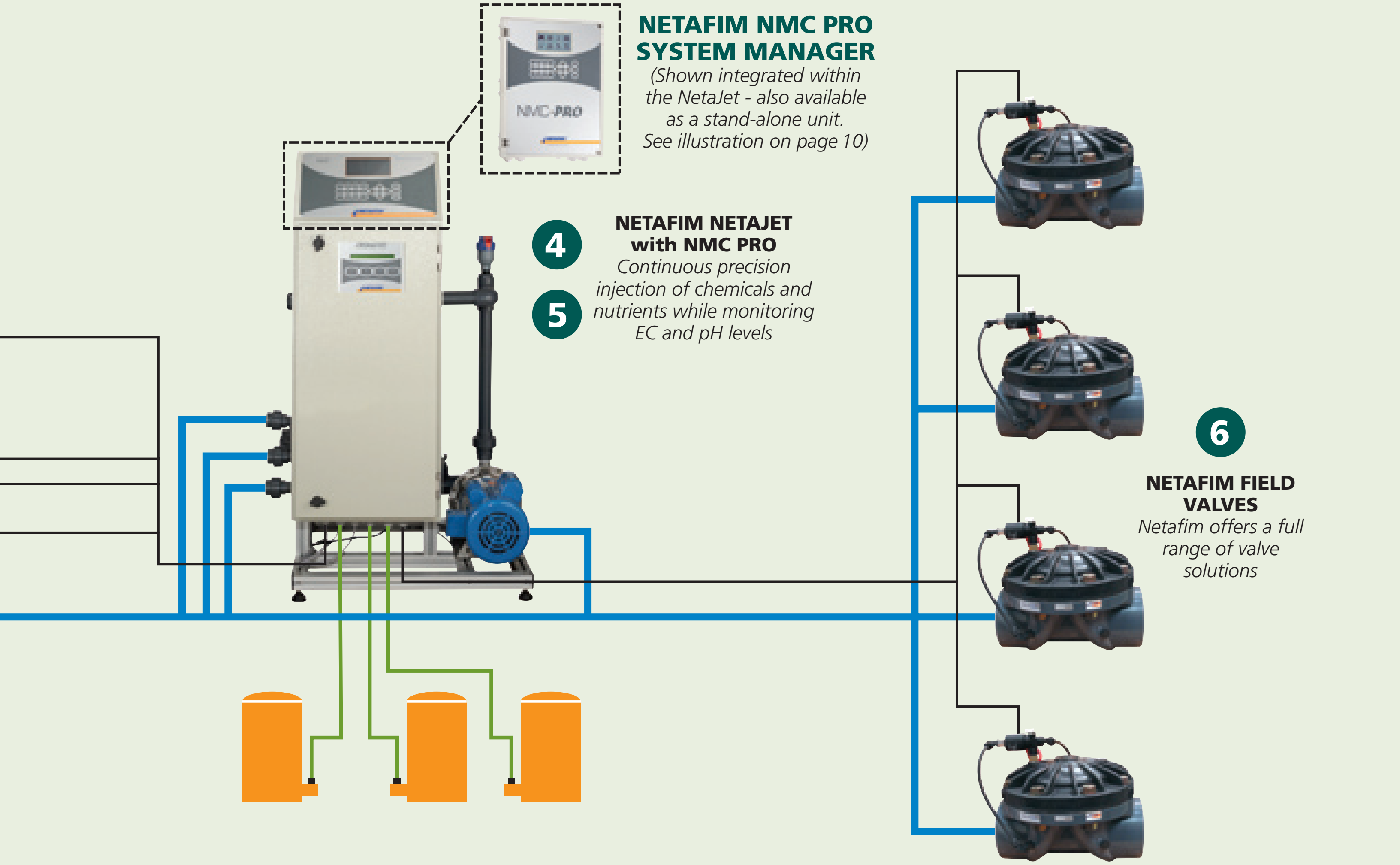


1 **Operates Main Pump(s) and Main Supply Valve(s)**

2 **Monitors, Controls and Logs Filter Backflushing and Controls Main Filter (Pressure Sustaining Normally Open - PSNO) Valve**

3 **Monitors and Logs Water Flow**

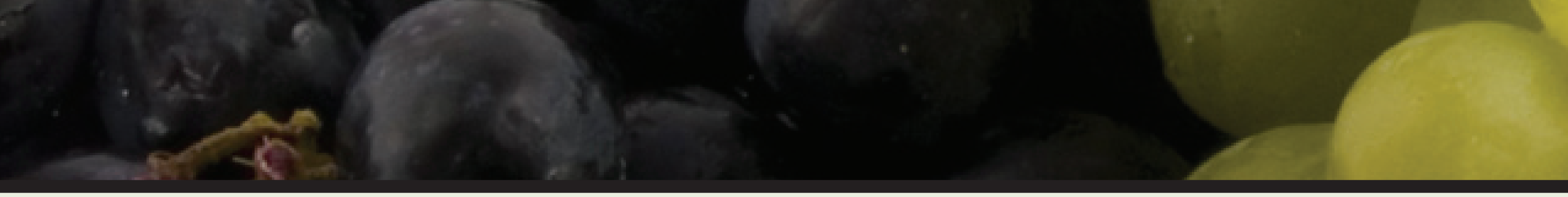




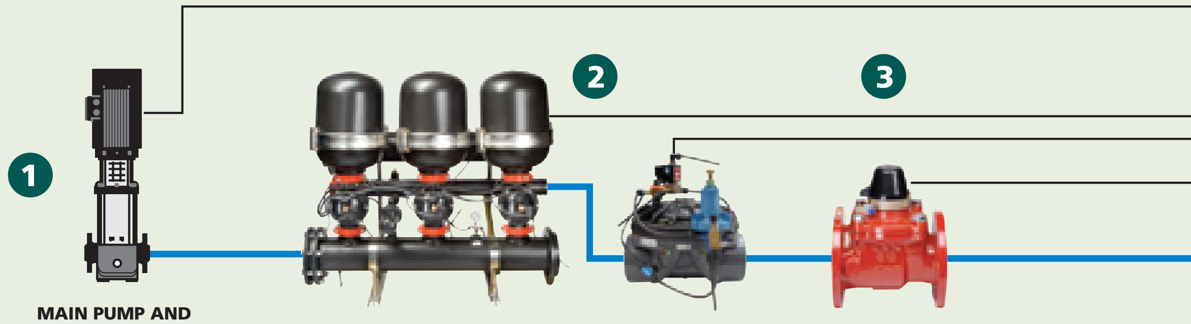
4 Controls Fertilizer and Chemical Injection

5 Monitors and Controls EC and pH Levels

6 Operates Field Valves



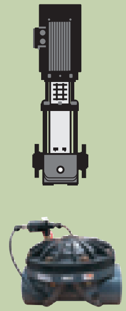
NMC Pro System Manager Does It All For You



1 6 Operates Main Pumps, Main Supply Valves and Operates Field Valves

The NMC Pro turns the main irrigation pumps or main supply and field valves on and off.

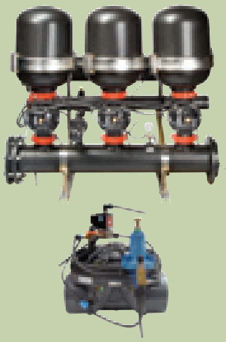
- Activates up to 6 main irrigation pumps or up to 6 main supply valves
- Differential operation of pumps based on real-time flow rates
- Schedules irrigation application totals via time or quantity with up to 15 irrigation programs
- Operates field valves via 24VAC solenoids
- Operates up to 60 valve run time programs
- Operates up to 255 irrigation field valves

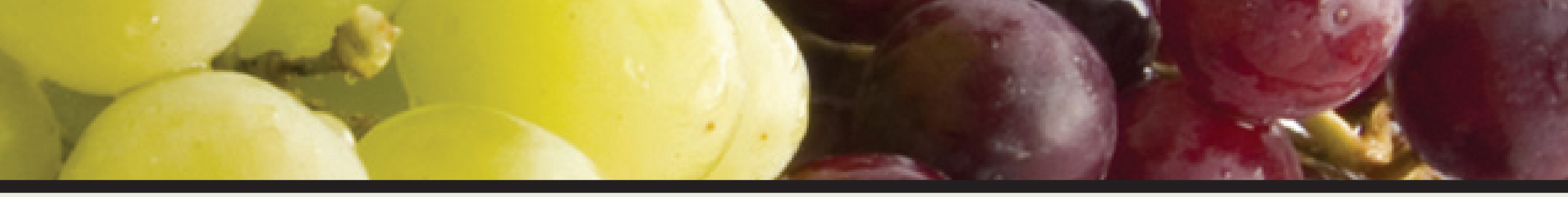


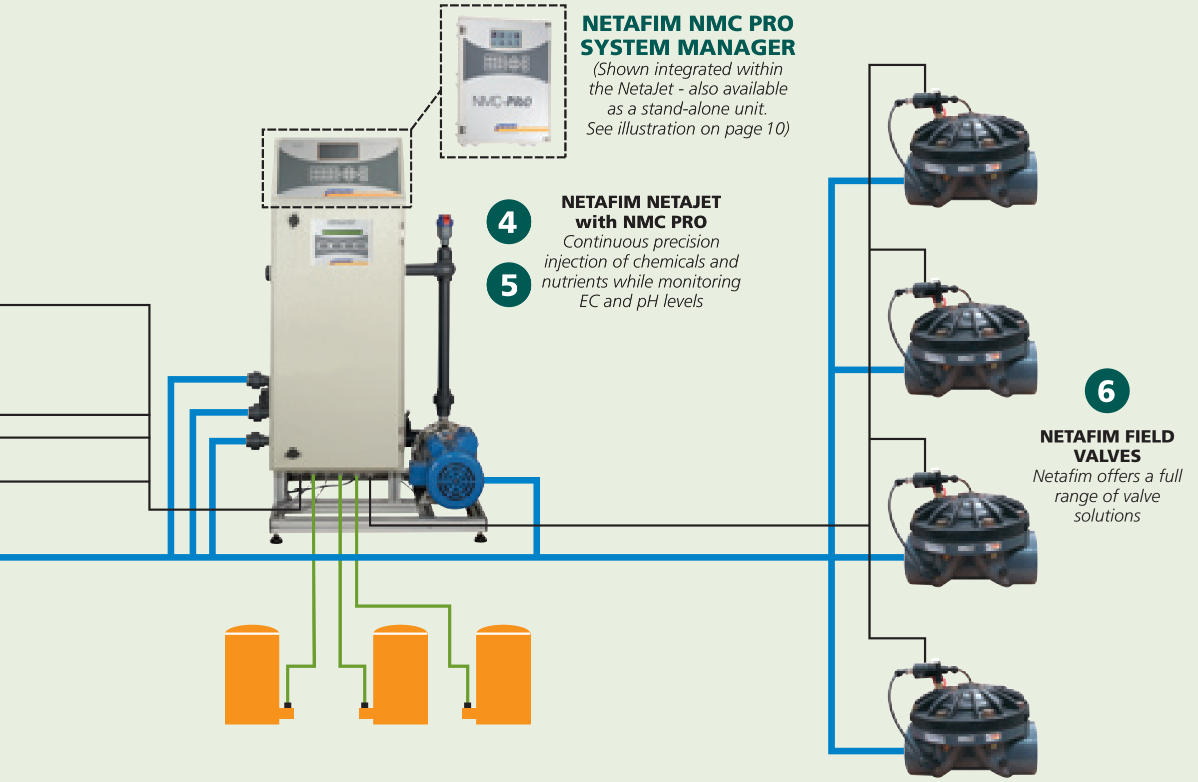
2 Monitors, Controls and Logs Filter Backflushing and Controls Main Filter (PSNO) Valve

Flexible programming options for filter backflushing eliminates the need for additional external backflush controllers. These programming options ensure smooth, reliable performance.

- Operates via time and/or pressure differential
- Programmable dwell/delay times for main filter valve and between individual filter units
- Records backflush history for easy troubleshooting and fine-tuning
- Programs and controls up to 24 individual filter units







3 Monitors and Logs Water Flow

Water flow is monitored and logged with recorded data for totals, limits, alarms and actions.

- Provides water flow data for setting flow limits
- Shuts down system based on high/low flow limits
- Records high/low occurrences as alarms
- Monitors and controls up to 6 water meters

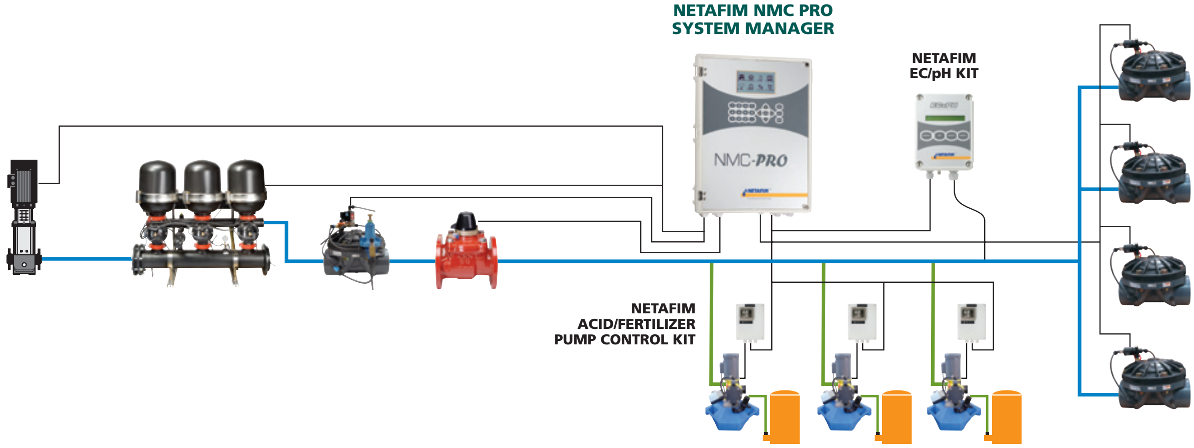
4 5 Controls Fertilizer and Chemical Injection and Monitors and Controls EC and pH Levels

Controls precision injection and dosing when combined with a compact unit such as a NetaJet.

- NetaJet offers three to five proportional dosing channels
- Precision injection based on time, quantity, EC and pH sensors or proportional to water flow for optimum system performance
- EC and pH programs do not have to use the same program parameters. As an example, fertilizers can be programmed to inject based on time or quantity while acid is programmed to inject based on proportion to water flow and pH set point
- Logs fertilizer meter flow rates and accumulates totals
- Maintains consistent pH level in most irrigation water ensuring maximum availability of nutrients within the root zone (especially in sub-surface irrigation)

Optional Kits for Fertilizer Injection and EC/pH Control

If you are not using an all-in-one injection and dosing unit like the Netafim NetaJet, optional control kits can be used to control fertilizer and chemical injection and monitor and control EC and pH levels through the NMC Pro System Manager (shown in the following system illustration).



Acid/Fertilizer Pump Control Kit
Item #77100-12020
For additional information see Page 14.

Fertilizer and Chemical Injection

An Acid/Fertilizer Pump Control Kit connects the NMC Pro to existing or new single phase injection pumps. Unique spread command calculates chemical injection over the entire irrigation period using real-time flow rates.

- Operates up to (8) Pump Control Kits simultaneously
- Injects by time, quantity, proportional time and/or quantity
- Requires an individual Pump Control Kit for each electric pump or injector
- Stops fertilizing during backflush cycles when needed

EC and pH Monitoring and Control

EC and pH data is displayed and transmitted to the NMC Pro allowing chemical injection to regulate EC and pH levels. The self-contained dual EC/pH transmitter has a menu driven calibration procedure and error reporting.

- pH control helps prevent plugging and chemical precipitation
- EC monitoring can be useful in controlling specific concentrations of fertilizers

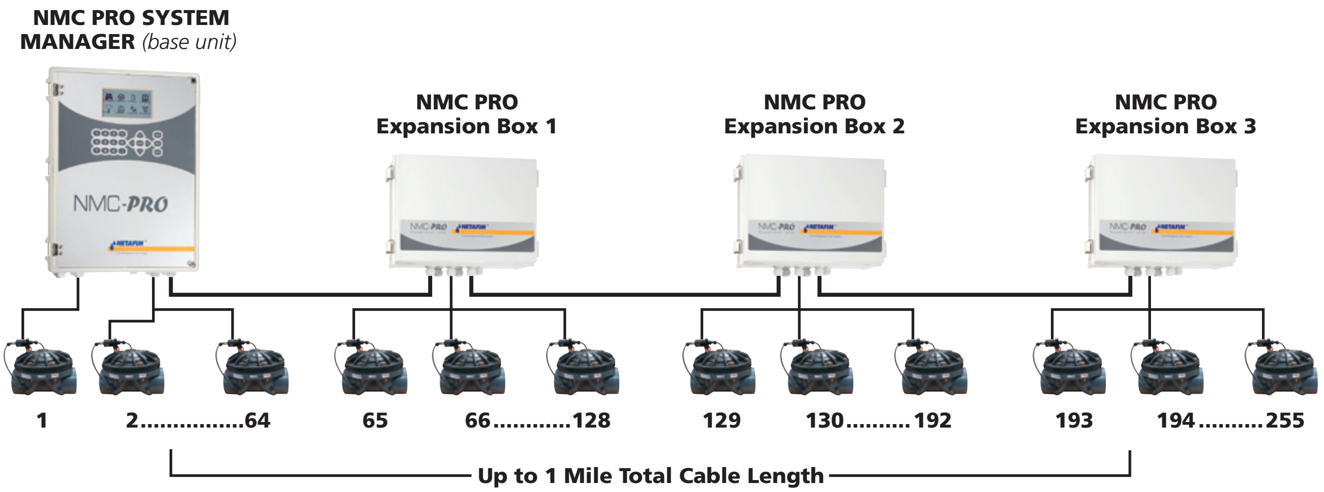
EC/pH Kit
Item #33000-003320
For additional information see Page 14.

A System That Grows at Your Pace

Now it's easier than ever to modify the system for growth changes. For growers needing more than 64 outputs, expandability is available with the Netafim NMC Pro Expansion Box. Each expansion box provides an additional 64 control outputs. Expansion boxes can run up to 1 mile from the NMC Pro System Manager base unit with simple two-wire communication. Maximum system control outputs (field valves) is a total of 255. For expansion capabilities over 1 mile and up to 6.2 miles from the base unit, the SingleNet Single Cable Control System is available. Contact Netafim USA Customer Service for more information on the SingleNet System.

The following graphic illustrates the simple expandability of the NMC Pro System Manager and the total number of control outputs (field valves) available with the addition of each expansion box.

NMC Pro System Manager (base unit)..............Control Outputs 1 through 64
NMC Pro Expansion Box 1................................Control Outputs 65 through 128
NMC Pro Expansion Box 2................................Control Outputs 129 through 192
NMC Pro Expansion Box 3................................Control Outputs 193 through 255



	Outputs	Digital Inputs	Analog Inputs
NMC Pro	64	32	22
Expansion Box 1	64	32	0
Expansion Box 2	64	32	0
Expansion Box 3	64	32	0
Total	Up to 256 Total	Up to 32 Total	Up to 22 Total

NMC Pro Expansion Box

Remote input and output terminal box that connects to the NMC Pro System Manager through a network connection and does not function independently. A maximum of three (3) expansion boxes can be connected to the NMC Pro System Manager.

NMC Pro Ordering Information

Use the NMC Pro Ordering Chart below to determine the NMC Pro System Manager and Components needed for your application.

NMC Pro Ordering Chart

						
	NMC Pro with Power Line Protector	**NetaJet**	**Acid/Fertilizer Pump Control Kit**	**EC/pH Kit**	**Temperature & Humidity Sensors**	**NMC Pro Expansion Box**
Item Numbers	**74340-003095**	**Call**	**77100-012020**	**33000-003320**	**74340-008200**	**74340-014100**

Call Netafim USA for NMC Pro System Manager spare parts and additional components.

NMC Pro Control Outputs and Inputs

NMC Pro Control Outputs

Control Outputs	Pumps	Filter Tanks	Main Filter Valve	Dosing	Agitator	Main Valves	Field or Zone Valves	Cooling	Misting	Alarms
Maximum Limit	**6**	**24**	**1**	**8**	**3**	**6**	**255**	**16**	**40**	**1**

Maximum combination of **256 total** outputs.

NMC Pro Control Digital Inputs

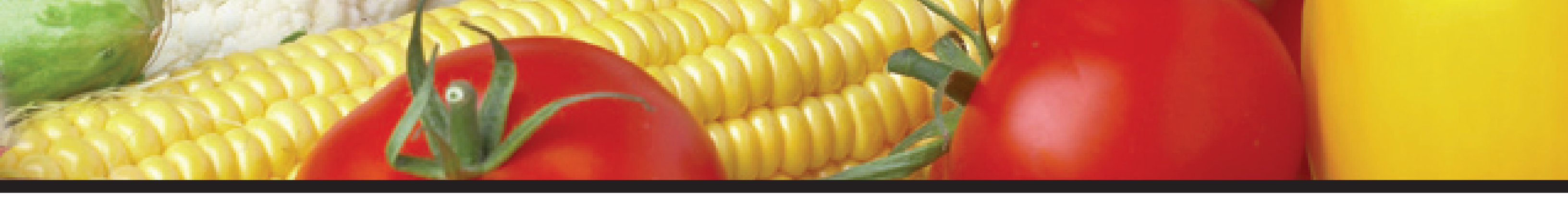
Control Inputs	Water Meters	Fertilizer Flow Meters	Pressure Differential Switch	General Inputs (Counters, Auxiliary Meters)
Maximum Limit	**6**	**8**	**1**	**26**

Maximum combination of **32 total** inputs.

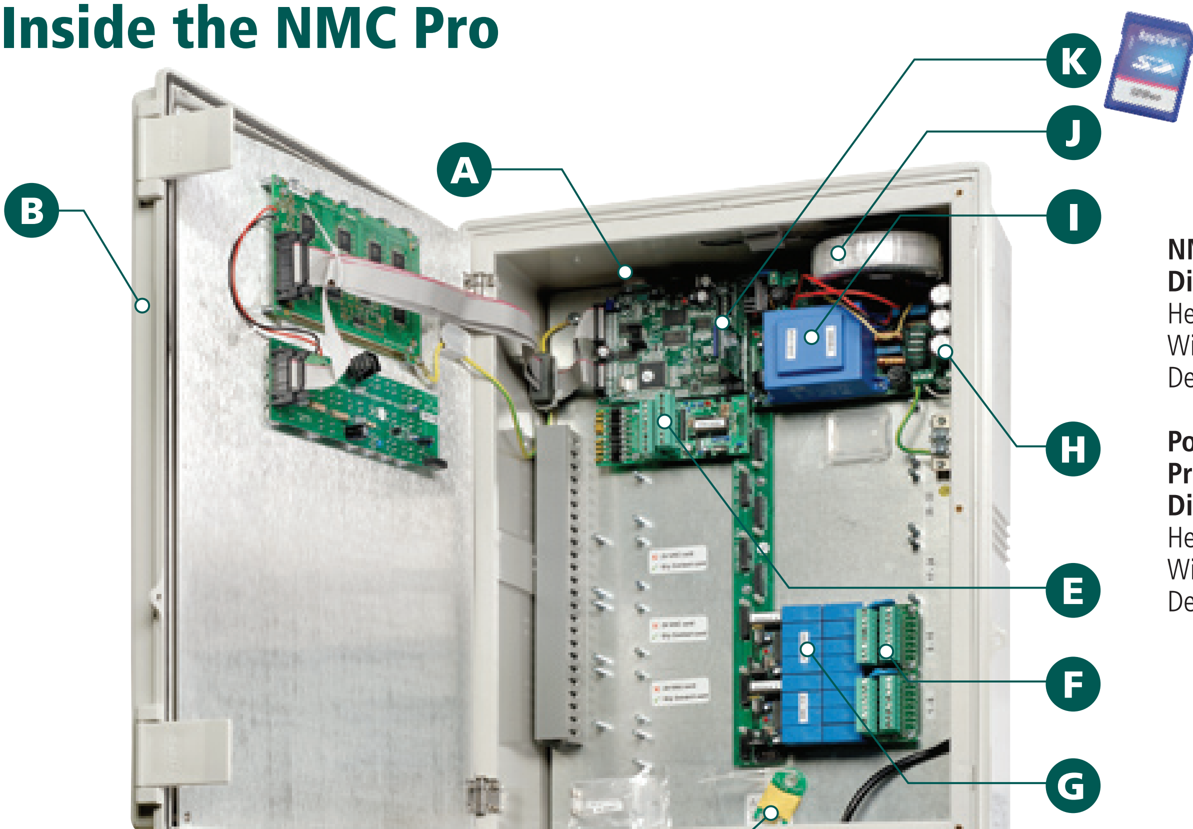
NMC Pro Control Analog Inputs

Control Inputs	EC and pH	Temperature	Relative Humidity	Pressure Transducer
Maximum Limit	**5**	**3**	**6**	**2**

Maximum combination of **22 total** inputs.

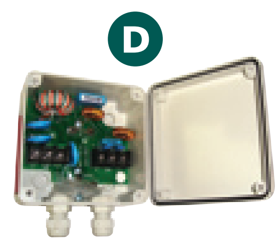


Inside the NMC Pro



NMC Pro Dimensions
Height: 19.5″
Width: 15.75″
Depth: 8″

Power Line Protector Dimensions
Height: 5″
Width: 4.25″
Depth: 2.25″



Standard with each NMC Pro

A **Lithium Battery Back-up -** ensures settings and logs are not lost due to power failure

B **Plastic Enclosure -** rugged all-weather reinforced plastic housing (IP 56) with screw-on lid withstands tough climates

C **Removable Memory Key -** no reprogramming needed to restore settings

D **Power Line Protector -** protects against power surges, plastic housing (IP 56), 115VAC, 50-60 Hz

E **Protected Input Connections**

F **Protected Output Connections**

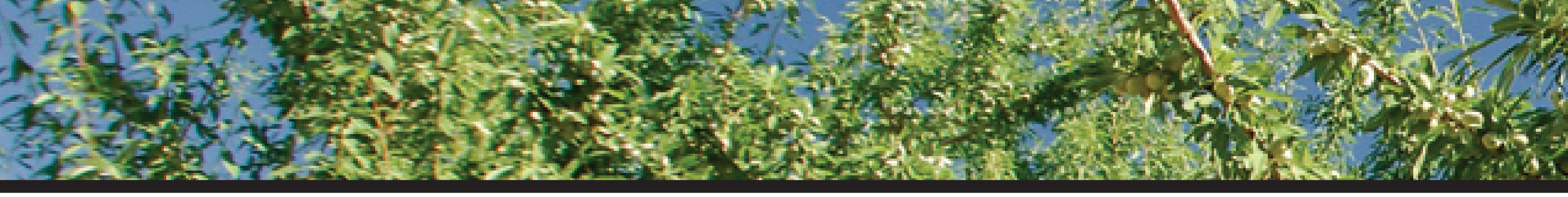
G **Output Relays -** 24VAC, 5 amp maximum

H **Power Filtering and Surge Suppression -** 120VAC surge suppression significantly increases reliability

I **Controller Power Supply Transformer**

J **Output Transformer**

K **SD Card -** for updating or upgrading software

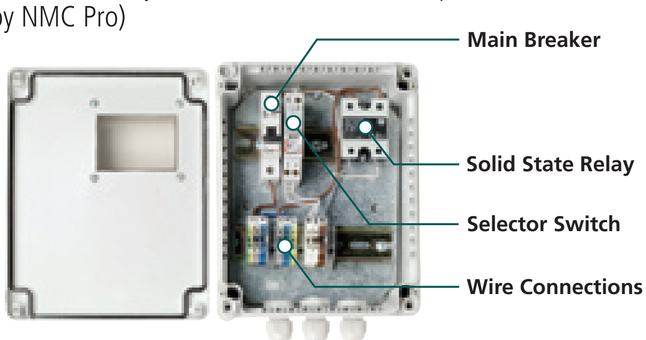


NMC Pro Optional Equipment

Acid/Fertilizer Pump Control Kit *(Item #77100-012020)*

The electrical control box of the Acid/Fertilizer Pump Control Kit connects the NMC Pro to existing or new single phase fertilizer/acid pump. Up to (8) Pump Control Kits can operate simultaneously.
A water resistant plastic box has a clear window for easy access to the main breaker and selector switch. The three position selector switch determines the pump operation.

M = Manual Operation (pump operates constantly when the switch is in this position)
A = Automatic (pump is operated by NMC Pro)
ST = Stop (Off)



Technical Specifications

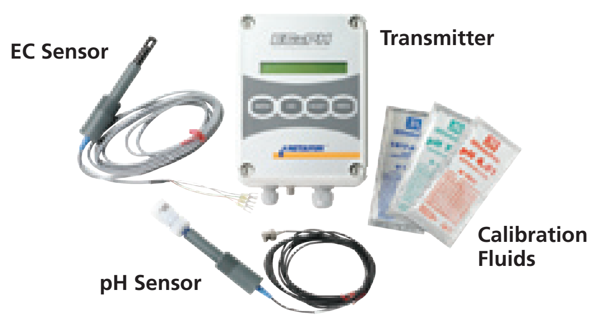
- Solid state electronic relay: 40 AMP
- Thermal protection for device: 10 AMP
- Input/Output power: 110VAC
- 24VAC Input from NMC Pro activates 40 AMP Relay
- Dimensions: 10 ¼″ H, 7 ½″ W, 4 ½″ D

EC/pH Kit *(Item #33000-003320)*

The EC/pH Kit includes a self-contained dual EC/pH transmitter, EC sensor, pH sensor and three packets of calibration fluids. EC/pH transmitter displays EC and pH with a menu driven calibration procedure within the unit. It also displays error reporting with easy to use troubleshooting instructions.

Technical Specifications

- Input Power: 24VAC
- EC Sensor Range: 0 to 10 mS
- EC Sensor Accuracy: 0.05 to 0.1 mS
- pH Sensor Range: 0 to 14
- pH Sensor Accuracy: 0.05
- Transmitter Dimensions: 9 ¼″ H, 6″ W, 3″ D



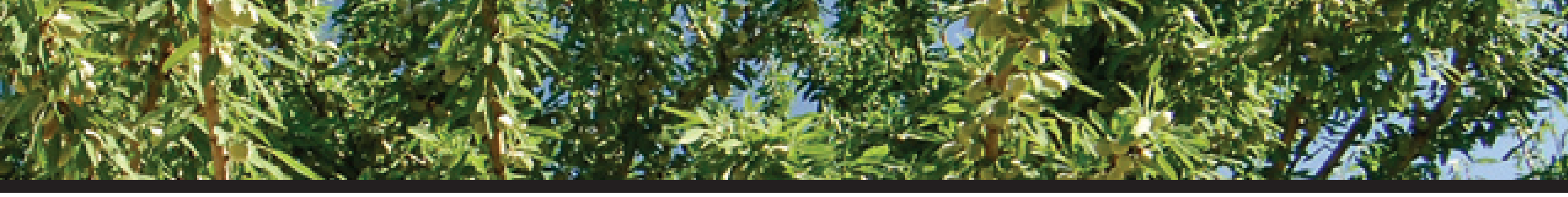
Temperature and Relative Humidity Sensors *(Item #74340-008200)*

This unit connects to the NMC Pro and contains one temperature and one relative humidity sensor. Data is graphed and shown on the LCD display. The sensors are on a passive radiation shield.

Technical Specifications

Temperature Sensor
- Type: 30 Kohm Thermistor
- Maximum Cable Length: 1,640′
- Operating Temperature: -75˚ to 320˚ F
- Accuracy: ± 2%

Humidity Sensor
- RH Range: 0 to 100%
- Maximum Cable Length: 1,000′
- Operating Temperature: 14˚ to 158˚ F
- Accuracy: 10% to 90% (± 2%)
  90% to 100% (± 3.5%)



Features for Nursery & Greenhouse Applications

Cooling/Humidification

The program can be configured for either cooling or humidification. It is used to keep the temperature below a set value and/or the humidity above a set value. Each program can be set to maintain temperature or humidity as its first priority:

- Up to 8 cooling/humidification programs with two periods in each program
- Periods can be defined to overlap, creating "dynamic" cooling or humidification
- Different temperature and humidity sensors can be connected to each program

Misting

The misting program is a time-based program that is used to open/close a misting valve or any other device that is operated sequentially and does not require the use of any sensors. It can be a part of or separate from the irrigation system. This gives you the flexibility to use these programs for automatic control of non-irrigation devices without interfering with your irrigation equipment:

- Up to 40 misting programs
- One misting valve per program

Additional Programs

The NMC Pro offers additional programs for Nursery and Greenhouse applications. Call Netafim USA for application specific information.

"Our fungicide savings are at least 15%"

"Our lives are so much easier since we installed the NMC System Manager on our 287 acre outdoor nursery," says Jamie Modlin. "It's really simple and easy to use - you don't have to be a rocket scientist." He programs irrigation schedules, filter flushing and runs the fertigation system. "Everything is in one program and the display is easy to read and follow," said Modlin.

At Long Creek Farms, controlling the fertilizer input through the fertigation system is resulting in over 10% savings on fertilizer costs. Modlin says they have decreased the amount of water put into the field through the drip irrigation system reducing the overall costs associated with irrigation operations.

"The quality of our crop has increased because we control the amount of water the plants are getting and we don't have to use as much fungicide. Fungicide savings are at least 15%. I've tried other landscape-type irrigation controllers, but they just don't work for my operation. They weren't designed with the features, capability, and ease of use like the NMC System Manager. We don't experience issues - the system is trouble-free," said Modlin.

Jamie Modlin -
Long Creek Farms & Nursery, Rocky Point, NC

Contact Your Netafim USA Dealer

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888.638.2346 • 559.453.6800
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A119 9/08

Appendix F

Irrigation Monitoring and Control System Design

Irrigation Monitoring Design Narrative and Supporting Data

Seaboard Group II and the City of Highpoint

October 12, 2010

By:
Rob Hibbs
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Table of Contents

Introduction

Contaminated groundwater originates from a former chemical manufacturing and recycling facility. The groundwater contains chlorinated voltatile organic compounds (cVOCs) and 1,4-dioxane which is migrating to a nearby reservoir. A series of groundwater recovery wells intercept this water at a rate of approximately 50 gpm year around. A treatment wetland is to be constructed to remove cVOCs via microbial reductive de-chlorination, however, 1,4-dioxane will pass readily through the wetland.

The 1,4-dioxane can be removed through transpiration via phytovolatization. A stand of trees was planted on the site, such that this reclaimed water can be utilized for irrigation, subsequently decontaminating the water.

This irrigation monitoring design consists of the components necessary to irrigate the tree plots with the reclaimed water, without increasing landfill leachate production. This design consists of a narrative, in conjunction with several drawings.

Location

Located in the State of North Carolina, Guilford County. Next to the City of High Point Landfill, within the City of High Point.

The site is situated up gradient of Randleman Reservoir.

Tree and Zone Details

There is approximately 50 gpm of water to reclaim year around, therefore both deciduous and coniferous trees were planted to utilize the water. Due to a lower water use requirement, there are more coniferous trees/zones than deciduous trees/zones.

Zone Number	Valve Number	Measured flow rate (gpm)	Drip Line Installed			Irrigation rate per acre (gpm)	Calc. acres
			Emitter spacing (ft)	Emitter rate (gph)	Emitters per acre		
1	1	54	1.50	0.42	2940	20.58	2.62
2	2	52	1.17	0.42	3769	26.38	1.97
3	3	57	1.17	0.42	3769	26.38	2.16
4	4	40	1.17	0.42	3769	26.38	1.60
5	5	58	1.50	0.61	2940	29.89	1.90
6	6	56	1.17	0.42	3769	26.38	2.12
7	7	57	1.17	0.42	3769	26.38	2.16
8	8	59	1.17	0.42	3769	26.38	2.24
9	9	50	1.17	0.42	3769	26.38	1.89
10	10	55	1.33	0.42	3316	23.21	2.37
11a	11	28	1.17	0.42	3769	26.38	1.06
11b	12	16	1.17	0.42	3769	26.38	0.61
12	13	53	1.50	0.61	2940	29.89	1.77
13	14	53	1.17	0.42	3769	26.38	2.01
14	15	45	1.17	0.42	3769	26.38	1.70
15	16	46	1.17	0.42	3769	26.38	1.66
Total							29.74

Table 1. Zone area and irrigation parameters.

Generally, deciduous trees are to be irrigated May through September (5 months). And coniferous trees are to be irrigated October through February, with alternating zones using the March and April irrigation. March and April are to be used to “flush” the soil of salt accumulation with rainwater.

Soil Characteristics

On-site soil characteristics were obtained from the Landfill Suitability Analysis and Pre Construction Report, Appendix B, referenced below.

Soil type	Soil Suction		Soil Moisture			WHC per foot (inches)
	Bars	kPa	% by mass	% by volume	Inches per foot	
Sandy loam	-0.33	-33	15	19.5	2.3	1.9
	-15	-1,500	4	3.1	0.4	
Loam	-0.33	-33	22	28.6	3.4	2.3
	-15	-1,500	7	9.1	1.1	
Silt loam	-0.33	-33	30	39	4.7	3.1
	-15	-1,500	10	13	1.6	
Landfill cover	-0.33	-33	17.2	22.4	2.7	1.5
	-15	-1,500	8.0	10.4	1.2	

Table 2. Soil Characteristics

Water Balance

Following are water balance data, assuming the irrigation time is split equally amongst the available plots. This is not taking into consideration zones not being irrigated due to soil conditions.

The water balance data are calculated utilizing climatic data from a “wet year”, and a “dry year”. The wet year/dry year is defined as a year with rainfall and ETo according to a 20 year return period. Climatic data derived from raw data obtained from the State Climate Office of North Carolina.

Tree water use required for the tree canopy to utilize 100% of applied irrigation and rainfall are listed in Table 3.

Coniferous Zones	**Tree Water Use – Dry Year (gallons/day)**	**Tree Water Use –Wet Year (gallons/day)**
Zone 1	6 to 16	11 to 20
Zone 2	9 to 15	11 to 19
Zone 3	9 to 15	11 to 19
Zone 4	10 to 15	12 to 21
Zone 6	9 to 15	11 to 19
Zone 7	9 to 15	11 to 20
Zone 8	9 to 15	11 to 19
Zone 9	9 to 16	11 to 20
Zone 11a	9 to 15	11 to 19
Zone 11b	9 to 15	11 to 20
Zone 12	9 to 16	11 to 20
Zone 14	10 to 17	11 to 21
Zone 15	9 to 16	11 to 20
Deciduous Zones		
Zone 5	37-43	42-48
Zone 10	30-35	34-39
Zone 13	33-39	39-44

Table 3. Daily tree water use required to utilize all water/rain applied, without utilizing soil storage.

Water Balance in a Dry Year

Figures 1 and 2, coniferous and deciduous trees, respectively, show a typical water balance for each zone over 12 months for a dry year. Irrigation divided equally among all zones for the entire duration, a 25% reduction in ET is included as a safety factor. A positive water balance means there is excessive rainfall/irrigation such that soil storage will come into play. A negative water balance means the trees will utilize more water than there is water being applied.

In a dry year, the Coniferous Zones always utilize more water than is supplied (irrigation plus rainfall). The months of December and January will be the months requiring close monitoring of irrigation supplied. The ability of supplying water during these months, due to snow and freezing conditions during this time will also dictate operation and alarm setpoints.

In a dry year, the deciduous trees will utilize all water thru August. September and October, with decreasing ET, soil storage will be utilized to contain the applied water within the root zone. During this time period, the continuous monitoring of soil moisture and drainage will be critical. And it can be decided to utilize the coniferous zones for taking excess water.

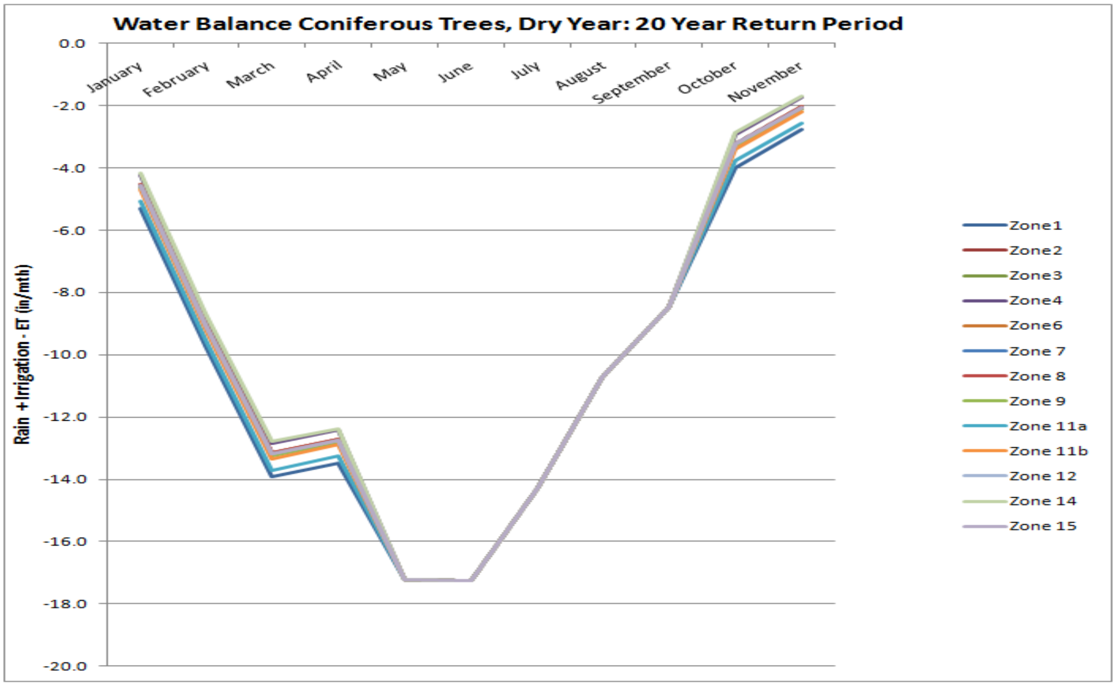


Figure 1.   Water Balance of Coniferous Zones for a Dry Year

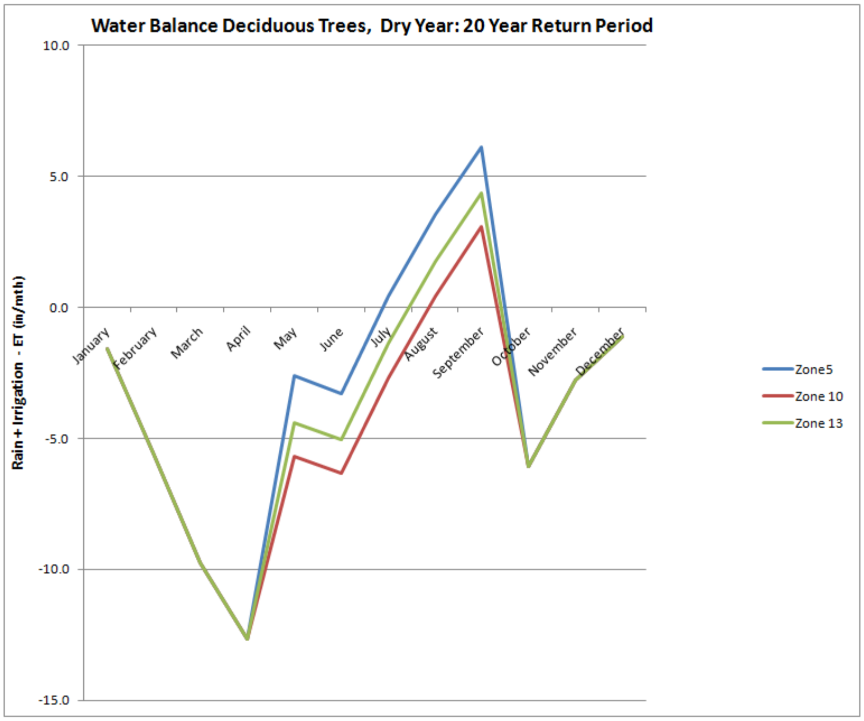


Figure 2. Water Balance of Deciduous Zones for a Dry Year

Water Balance in a Wet Year

Figures 3 and 4, coniferous and deciduous trees, respectively, show a typical water balance for each zone over 12 months for a wet year. Irrigation divided equally among all zones for the entire duration, a 25% reduction in ET is included as a safety factor.

In a wet year, the Coniferous Zones utilize more water than is supplied (irrigation plus rainfall) until December and January. The months of December and January will be the months requiring close monitoring of irrigation supplied. The ability of supplying water during these months, due to snow and freezing conditions during this time will also dictate operation and alarm setpoints. A turn-key, preferably automatic, method of diverting water to the physical treatment system for such conditions is required.

In a wet year, the deciduous trees cannot sustain irrigation with all of the reclaimed leachate, as evidenced in Figure 4; there is a monthly excess of 2 to 6 inches of water per month.

A management option, in this case, is to deliver some of the leachate to the Conifer Zones during the summer, as described in the next section.

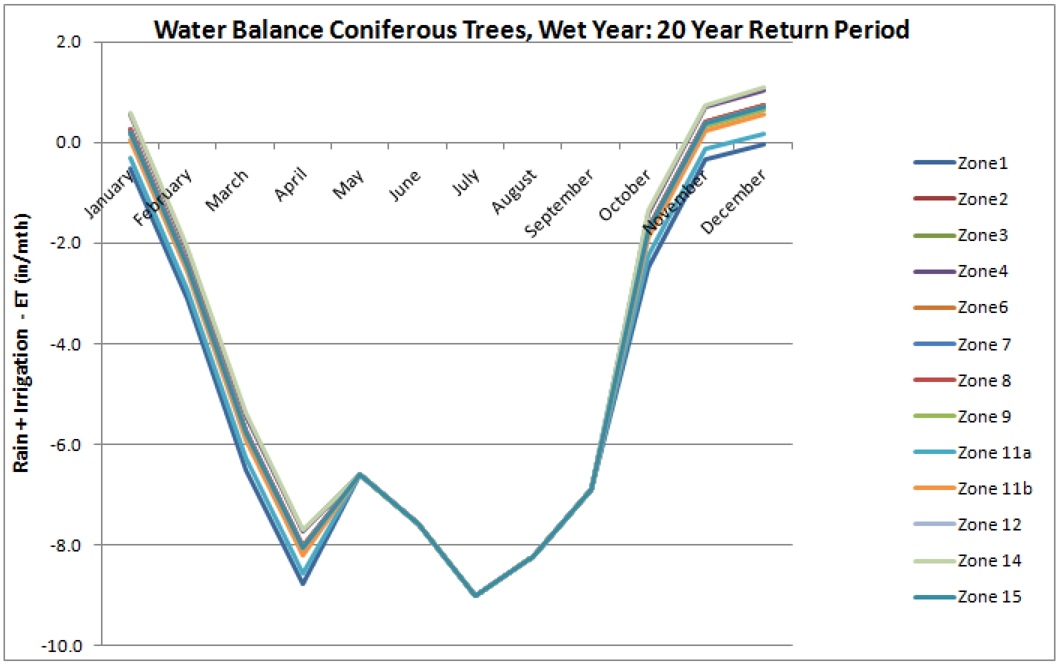


Figure 3. Water Balance of Coniferous Zones for a Wet Year, not irrigated in Summer

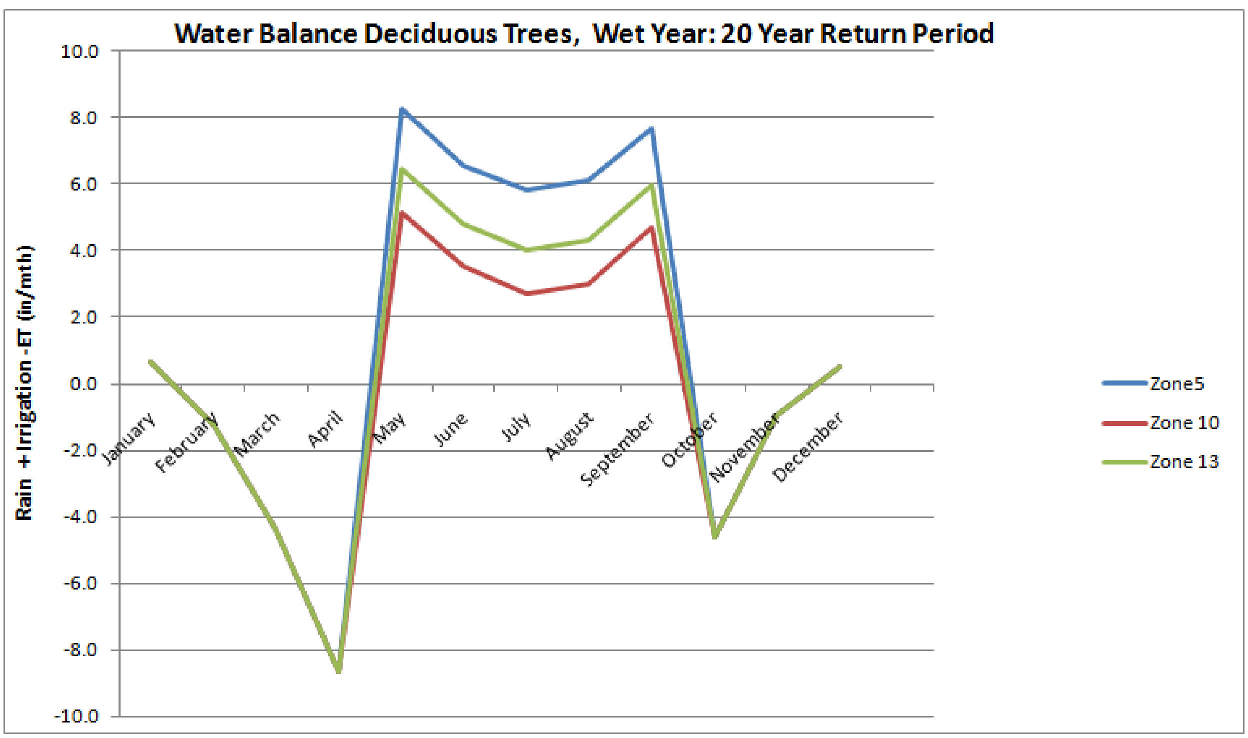


Figure 4. Water Balance of Deciduous Zones for a Wet Year, irrigated 8 hours per day thru Summer

Water Balance in a Wet Year, Splitting Summer Irrigation with Conifers

Figures 5 and 6, coniferous and deciduous trees, respectively, show a typical water balance for each zone over 12 months for a wet year. However, irrigation to the deciduous plots is cut in half (4 hours per day), while the rest of the irrigation is diverted amongst the conifer plots.

The Coniferous Zones continue to utilize all of the supplied (irrigation plus rainfall) water, while the Deciduous Zones now fall into sustainable patterns of water use.

For the system, this means that we must monitor, on-site, the current and accumulated ET and rainfall. And, this data must be available to the controller for both irrigation control and alarm status.

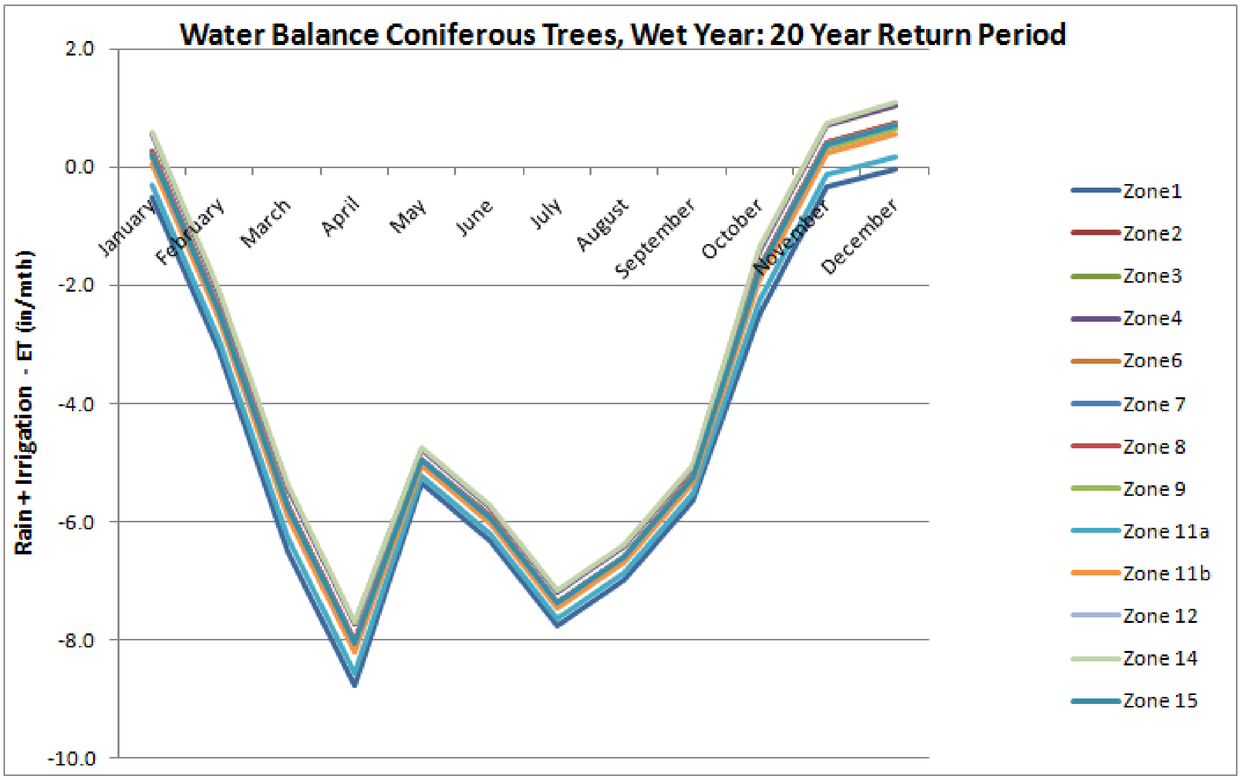


Figure 5. Water Balance of Coniferous Zones for a Wet Year, Summer irrigation split with Deciduous

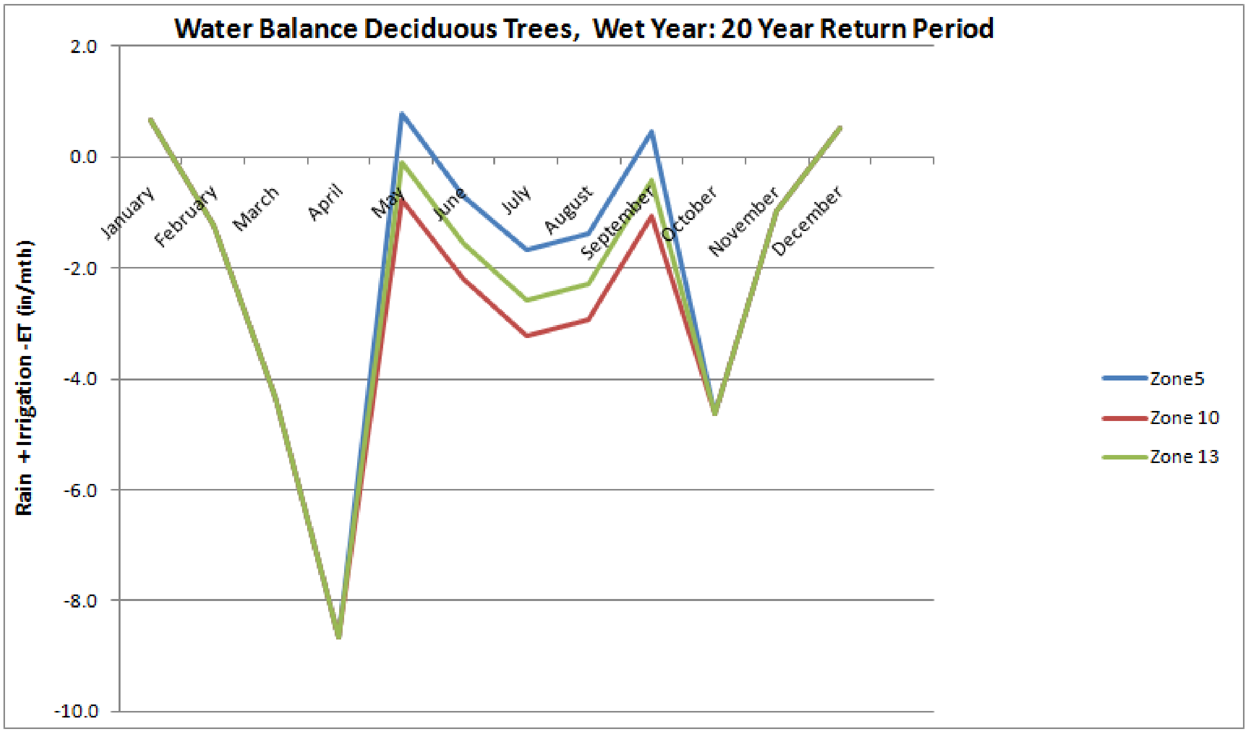


Figure 6. Water Balance of Deciduous Zones for a Wet Year, Summer irrigation split with Conifers

Monitoring Climatic Conditions

On-site monitoring of climatic conditions is extremely important for this application. The soil moisture data is needed, but this is a "static" measurement and therefore doesn't show the relative rates or potential for water movement. The weather data, via rain and ET, show relative rates of evaporation/water use and rain.

The overall water balance of rain, irrigation and ETo is the first means of adjusting irrigation schedules such that water is distributed among the zones according to transpiration. This data will be used as a predictive tool to avoid, or minimize, the need to shutdown irrigation to a zone due to increased soil moisture.

The amount of land/trees available to utilize the leachate water is limited, and the overall site water balance needs to be monitored continuously, continuously available for control decisions, and continuously calculated for alarm notifications.

Specifically, a weather station measuring or calculating the following items is needed:

- Wind speed and direction at 10 meter (32 ft) height
- Solar radiation at 2 meter (6.6 ft) height

- Air temperature at 2 meter (6.6 ft) height
- Relative humidity at 2 meter (6.6 ft) height
- Rainfall
- Soil temperature at 5 cm (2 in) depth
- Soil temperature at 45 cm (18 in) depth
- Barometric pressure is optional
- ETo calculated from above parameters utilizing a Penman-Monteith based equation

The surface beneath the weather station should be natural vegetation/grass which is mowed or maintained at a regular interval to keep the vegetation height less than 6".

The best location for the weather station is listed on the IRR-1 drawing. The soil and access to the weather station needs to be solid enough to support routine access, and to stabilize an aluminum 30 foot tower.

A diagram of the weather station is listed in drawing IRR-4.

Monitoring Soil Moisture and Conductivity

Soil moisture is the determinant in whether irrigation can be adjusted, proceed, or should be stopped, in the applicable plots.

0 to 3 Foot Depth

Soil moisture monitoring in the 0 to 3 foot range is the most important, as this is the area of primary available storage capacity. This capacity, with 7.5 inches of available storage, can be monitored with two sensors per location. One at a depth of 12", and the other at 30".

The primary sensor specified is the Decagon 10HS Soil Moisture sensor. This will give comparable data to that obtained from alternate sensors in the trial plots, is easier to install, and is cost efficient.

In select locations through the plots, combination conductivity/soil moisture sensors are specified to give a continuous feed of baseline conductivity data. This sensor is to be placed as the top sensor (12") at those locations specified. The specified sensor is the Decagon 5TE Sensor.

3 to 6 Foot Depth

The 3 to 6 foot depth does contain approximately 6.3 inches of available soil water storage, and the trees should utilize this soil for replenishment. However, data from the pilot studies as well as on-site observations of standing water and soil slopes indicate that the moisture can become saturated and stay saturated for some time.

As a management tool, it would valuable to know if this zone is saturated or not. Also, whether the trees are actively utilizing this zone for obtaining water. This can be accomplished with a single Irrometer Watermark Soil Moisture sensor at that location. The Watermark sensor should be placed at a depth of 48 inches.

Monitoring Stations

Monitoring stations, the measurement stations making and recording the environmental data, are spread out among the zones, as shown in IRR-1. The stations are grouped into pairs, having a primary and secondary monitoring station as shown in the drawing IRR-2 & IRR-3. The pairs will be connected by a single 4-conductor cable buried slightly underground in conduit.

The primary monitoring station is responsible for three items 1) measuring local soil moistures, 2) retrieving data from the secondary monitoring station, and 3) reporting data from both stations to the East or West Lobe Repeater. Communication from the Primary to the Secondary station is done via a buried cable, and utilizes SDI-12 Communication. Communication from the Primary station to the East or West Lobe repeater is via spread spectrum radio.

The following table lists the stations and the monitored variables at each location.

Station Name	***Station Type***	***Monitoring***	***Sensors***
Z1_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z2_1_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z3_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and	1 5TE @ 30”

		Conductivity @ 30”	
		Saturation @ 48”	1 Watermark @ 48”
Z4_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z4_2_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z6_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z5_1_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z6_2_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z5_2_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z8_1_SM	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z7_1_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z10_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z9_1_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z9_2_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z11A_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”

		Saturation @ 48”	1 Watermark @ 48”
Z1_2_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z11B_1_SMD	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z12_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z12_2_SM	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z13_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z13_2_SMD	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z14_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z14_2_SMD	Secondary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”
		Drainage	1 Draingage
Z15_1_SMC	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture and Conductivity @ 30”	1 5TE @ 30”
		Saturation @ 48”	1 Watermark @ 48”
Z15_2_SM	Primary	Soil Moisture12”	1 10HS @ 12”
		Soil Moisture @ 30”	1 10HS @ 30”
		Saturation @ 48”	1 Watermark @ 48”

Monitoring Flows – System Efficiencies

Several flowrates through the system must be continuously monitored with flowmeters, this is to be part of the physical design. The PLC for the physical design will transmit a continuous signal to the irrigation system for overall system monitoring by the consultant. For each, the PLC will transmit a continuous signal of flowrate (4-20 mA), rather than total flow, unless the flows are very slow and intermittent in which case a signal of total flow can be transmitted.

- Leachate Production (M1) (FIT121 in Drawing I3) - This is the variable we are trying to minimize, and can be used by the consultant as a reference.
- Recovered Groundwater (M2) (RW6-FIT120; RW7-FIT130; RW8-FIT213 in Drawing I3 & I4) – This is the second input into the overall system, this data is needed for efficiency calculations as well as proper system operation.
- Flow to the Irrigated Plots (M3) (FIT581 in Drawing I6) - This is a crucial component in keeping the phyto system's continuous water balance. Only total flow/flowrate is required, not flow to each plot; as the irrigation controller "knows" which valve is open, and can therefore determine and log flow to each plot. The system is designed to only irrigate one plot at a time.
- Flow to the POTW from the Physical Treatment System (M4) (FIT400D in Drawing I6) – Critical component in determining overall system efficiency. Any increase in water to the POTW is not wanted and expensive, and must be monitored.
- Flow from the Metal Removal System to the Treatment Wetland System (M6) (FIT410 and FIT20 in Drawing I7) - The combination of M6 and M7, gives us the effectiveness of our treatment wetland system.
- Flow from the Treatment Wetland System back to the Physical System (M7) (FIT450 in Drawing I7) – The combination of M6 and M7, gives us the effectiveness of our treatment wetland system.

Monitoring Wetland Pond Water Level

In the full scale system, the wetland treatment system is a necessary component in removing cVOCs. Proper operation of the wetland system is necessary. Monitoring the water level will provide automated feedback to the system operator of system failures, such as unexpected wetland drainages, clogged or broken supply pipes, etc. This can also be used by the irrigation consultant for overall system monitoring.

The Physical System design is going to monitor treatment pond water level, in both Cell 1 and Cell 2, and deliver this data to the Environmental Master Station via a 4-20mA analog signal.

Communication and Data Retrieval

System Data Access

Communication and data collection for the system are to be achieved via a cellular internet connection/modem, accessed by an IP Address. This will enable multiple data collection sources, and alarm text/e-mail alarm notifications.

Communication Between Primary Stations

Communication between most stations are to be via spread spectrum radio. Three stations are to be used as major communication/repeater hubs. These are 1) the Master Station, 2) the West Lobe Repeater Station, and 3) the East Lobe Repeater/Weather Station.

Four stations are to communicate to nearby stations via SDI-12 Communication (Serial Digital Interface-12Volts). This is because these four stations are on the backside of plots and may be harder to keep good radio communication in the future. These stations are 1) Zone 5/6 North Stations, 2) Zone 8/9 North Stations, 3) Zone 14 Stations, and 4) Zone 15_2 Station. A buried, contained in conduit, twisted pair communication line is to be installed to the nearest station for these stations. This cable can be installed within the same conduit that is supplying power to the stations.

Communication Between Primary and Secondary Stations

Communication between the primary and secondary stations is to be via SDI-12 Communication (Serial Digital Interface-12Volts). A buried, contained in conduit, four conductor communication and power cable is to be installed between the primary and secondary station. This cable is to be installed within buried conduit.

Power and Power Distribution

Low voltage power is distributed to all primary monitoring stations. Nearby secondary stations receive 12VDC power from the primary station.

East and West Power Stations

There are two primary power panels, one for the West Lobe and one for the East Lobe. At the location of these panels, 110VAC is necessary to power the transformer. There is already power at the West Lobe location. These Power Stations contain a fuse protected 22VAC Power transformer to supply power to the Power Junction Boxes.

Cable to the Power Junction Boxes is to be 3-wire 14 guage cable, buried within grey electrical conduit (1 ½” diameter minimum). All conduit bends to be made with electrical sweeps.

Power Junction Boxes

The power junction boxes provide three purposes 1) provide a junction box for power coming from the Power Station (East or West), 2) provide fuse-limited protection from one box to the next, and 3) provide fuse-limited power to the nearby station(s).

All power junction boxes are to provide 22VAC, Common and Ground terminals originating from the Power Station.

Irrigation Master Station

The Master Station is to be located near the control trailer. Following are the duties of the Master Station:

- Communicate via radio to the East and West Lobe Repeaters
- Monitor/measure all flows and parameters relayed via the physical system.
- Be accessible to other computers via the internet (cellular IP Address), this includes the base master station.
- Store/log and process all moisture, flow and irrigation data.
- Accept and process irrigation control requests.
- Control irrigation to all plots, at all times, according to time, weather, moisture and drainage.
- Administer alarms to appropriate personnel via e-mail or text message.

The CPU of the Master Station is to be the Campbell Scientific CR1000 Micrologger, and associated peripherals.

Alarms

Alarm conditions are to be relayed to appropriate personnel according to the severity of alarm. A secondary alarm is used to warn the operator of pending problematic conditions. This alarm is not an emergency, but should be noticed by the operator.

A primary alarm is an emergency alarm, where the operator is notified visually, as well as via a text or e-mail message.

Some samples are below:

Primary Alarm (Emergency)	Secondary Alarm (Visual Notification)
Irrigation called for, but not received	Sensor out of bounds
Plot saturated, irrigation occurring	Plot saturated, no irrigation
Pond water level below limit	High Water Applied Factor
	Low Water Applied Factor, sensor not drying

The Irrigation Controller Decision Matrix

Determination of irrigation quantities and timings are to be based upon the following variables:

Consistent (Fixed) Variables	Monitored Variables
Long term weather records	Real-time weather (ET)
Irrigation application rates per zone	Real-time weather (Rain)
Tree maturity/water use stage	Soil moisture in 1-3 foot range
Soil moisture release curves per zone	Soil moisture/saturation in 3-6 foot range

Step 1 – The Consultant

On a monthly or quarterly basis, the Consistent Variables need to be analyzed along with the recent Monitored Variables to determine "design" irrigation schedules and setpoints for input to the controller. This is the initial "design" irrigation schedule for the time period. The controller will then make the real-time/control decisions in the field.

Step 2 - The Zone Rotation

At any one time there will be a set of zones that are "available" for irrigation, these zones are "in the rotation". Irrigation is to proceed from one zone to the next according to the expected schedule. Zones may be added or subtracted from the rotation in three ways, 1) the Consultant via the design schedule, 2) the controller based on monitored variables, and 3) the Operator based on on-site observations and maintenance.

The controller will remove a zone from the rotation based on soil moisture greater than the setpoint. The controller can also add the zones back into the rotation based on the same parameters.

Primary Zone Rotation

There will be a set of zones to receive the bulk of the irrigation during a time period, these zones are in Primary Irrigation Rotation.

Secondary Zone Rotation

There may also be a set of zones to receive "extra" irrigation that can't be handled by the Primary Zones, these zones are in the Secondary Rotation. For example, during the summer, the Primary Zones will be the Deciduous Zones, however, there may be some Coniferous Zones that the Consultant would allow to take extra water during periods of low ET/high rainfall. In addition, the Coniferous Zones could be in the Secondary Rotation during the early stages of tree maturation before the Deciduous Zones can handle the 50gpm design flow.

Step 3 – The Soil Moisture

Soil moisture characteristic curves were evaluated, see the Pre Construction Report Appendix B and Reference 6: Ari Ferro, June, 2010.

Soil moisture will be the determining factor in whether irrigation can proceed as scheduled or not. The goal is to utilize all of the available soil moisture holding capacity in the 0 to 6 foot rooting depth. A soil moisture set point will be utilized, specific to each zone, such that irrigation can proceed or not. The specific set points will be determined by the Consultant for that time period. All monitored depths would need to be above the setpoint for irrigation to be stopped.

Determination of the “design” soil moisture setpoint is to be completed by the Consultant for a given time period. This value will be in the range of -4kPa to -10kPa, as discussed in Appendix B of the Preconstruction Report.

Step 4 – The Weather

Tree water use is directly related to ET, as is seen in supporting data, in the Seaboard Preliminary Construction Report, Appendix A, 9/30/2010. And irrigation schedules were adjusted based on weather, which is a necessity with any irrigation system. The weather station gives the controller the means to automate some of these adjustments, rather than relying on operator/consultant intervention.

The application rate to the trees in any one zone is fixed, and therefore, the controller’s options are to reduce the allotted time for irrigation per zone, add or subtract zones to be irrigated, or to stop irrigation. The monitored weather will be the first variable to modify the irrigation time/zones watered.

Daily and cumulative ET are to be calculated by the irrigation control system. The Consultant will input the “design” ET’s for a given time period. A Water Applied Ratio equal to (Irrigation + Rain)/ET will be calculated hourly for daily, weekly and monthly totals. This ratio will be calculated for each zone, as each zone has a different mix of trees (different ET) and will have different irrigation applied volumes.

The controller will adjust irrigation schedules for the plots based on the Water Applied Ratios, in conjunction with soil moistures. A high Water Applied Ratio and a high soil moisture level for a plot, would automatically trigger diverting this flow to another plot, by increasing the amount of time another plot is irrigated, or by adding in a different zone to irrigate.

On the computer screen, the Operator will have a grid, or map, of the plots with weekly Water Applied Ratio’s, as well as soil moisture. Alarm conditions can be triggered from either Water Applied Ratio’s or soil moisture.

The Water Applied Ratio gives the controller a relative indicator of the dynamic rate of water application compared to tree water use for each plot. Soil moisture, a static variable at any one time, is necessary to see the effects of water application/water use. By the time the "state" of soil moisture is at the setpoint, other areas in that plot may have met or exceeded this value. This can be avoided in many cases, by simply adjusting the irrigation schedule for that zone beforehand due to a high Water Applied Ratio.

The Water Applied Ratio can also be a means for alarm:

A high Water Applied Ratio – Irrigation/Rain in Excess

A low Water Applied Ratio - Soil moisture sensors not drying; Check sensors

Measured rainfall will influence irrigation schedules by affecting the Water Applied Ratios, and estimated water balances.

Computer Base

The computer base will host the communications software, Loggernet Version 4, as well as a custom computer display for the operator, created with the software program RTMC (Real Time Monitoring & Control).

The software requires a standard Windows Operating system, with an internet connection.

The computer display/operator interface will be built, the format and design to be submitted for approval by representatives of the Seaboard group.

Screens/information to include in the operator interface will include at least the following:

- Grid, or site map, with soil moistures and ET ratios
- Current weather screen
- Historical weather screen (last week or month)
- Visual Alarms
- Operator Interface parameters

List of Drawings

The following drawings consist of design details.

Drawing	Description
IRR-1	Site Layout
IRR-2	Monitoring Station, Sensor Placement and Installation
IRR-3	Monitoring Stations
IRR-4	Weather Station and West Lobe Repeater
IRR-5	West Lobe Repeater

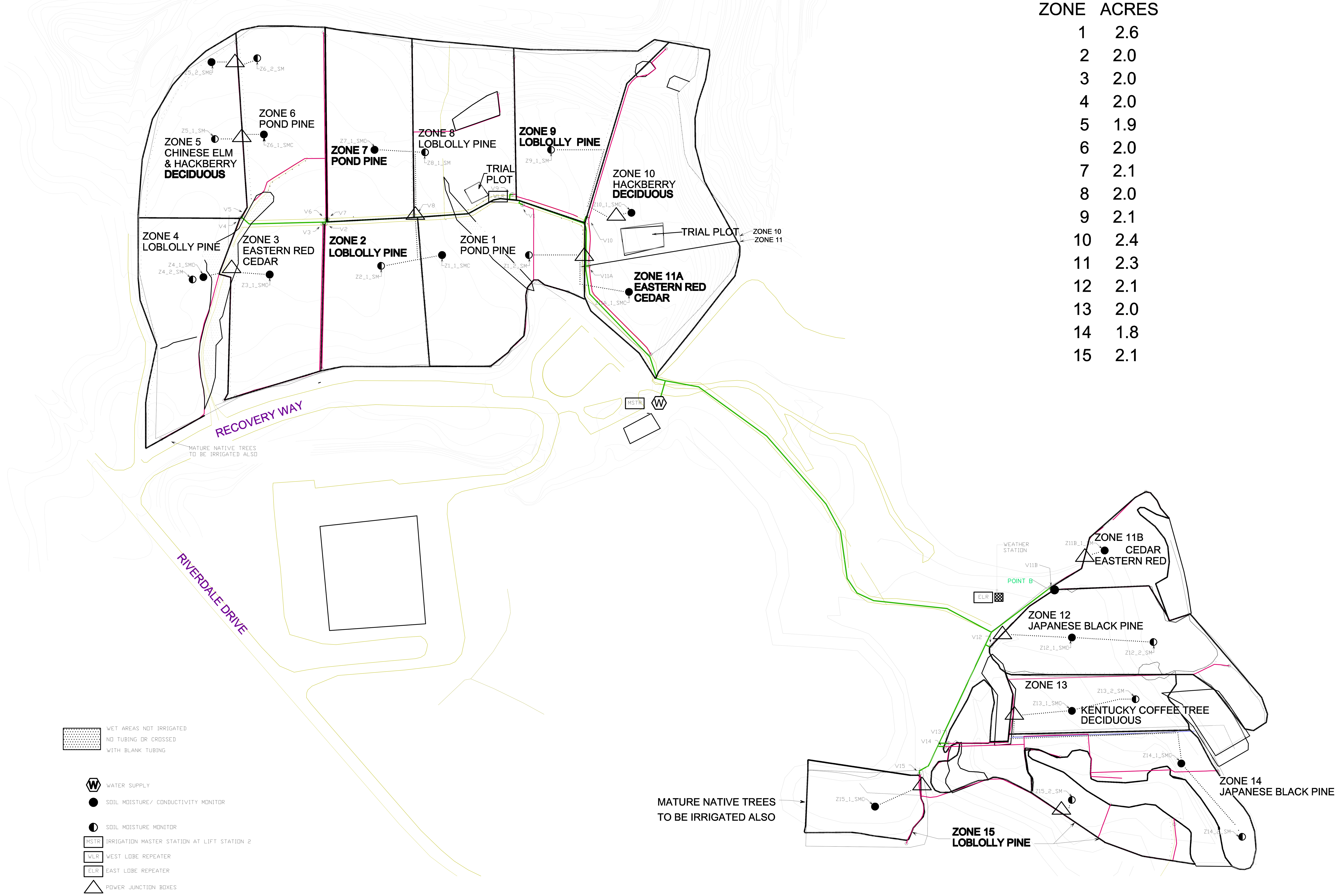
IRR-6	East Lobe Power Supply
IRR-7	Irrigation Master Station

References

1) ENSR, 2006. Landfill Suitability Study. June, 2006.
2) Ferro, A. Assessing the Hydrologic Water Balance for the Mature Upland Phytoremediation System at the Former Seaboard Chemical Corporation Facility and the City of High Point Landfill. Draft Report, June 27, 2006.
3) Ferro, A.M., Tammi, C.E.. Field Note: Irrigation of Tree Stands with Groundwater Containing 1,4-Dioxane. International Journal of Phytoremediation, 11:425-440, 2009.
4) Ferro, A.M. 1998. "Biological Pump and Treat Systems Using Poplar Trees." Presentation at IBC's 3rd Annual International Conference on Phytoremediation. Houston, TX, June 22–25, 1998.
5) Ferro, A.M. 2009. "Treatment Routes for GW/L." Memorandum for Seaboard Group.
6) Ferro, A.M. June, 2010. "Soil Water Characteristic Curves Composite Soil Samples from the Fifteen Irrigation Zones."
7) Ferro, A.M. October, 2010. "Seaboard Group Pre-Construction Report for the Phytoremediation System."
8) Hibbs, R.A. 2010. "Conference Call Agenda 1-22-10." Agenda for Seaboard Group Conference Call. February 3, 2010.
9) State Climate Office of North Carolina, NC CRONOS Database, stations KGSO-Greensboro Airport and 314063-High Point.

31.4 TOTAL ACRES

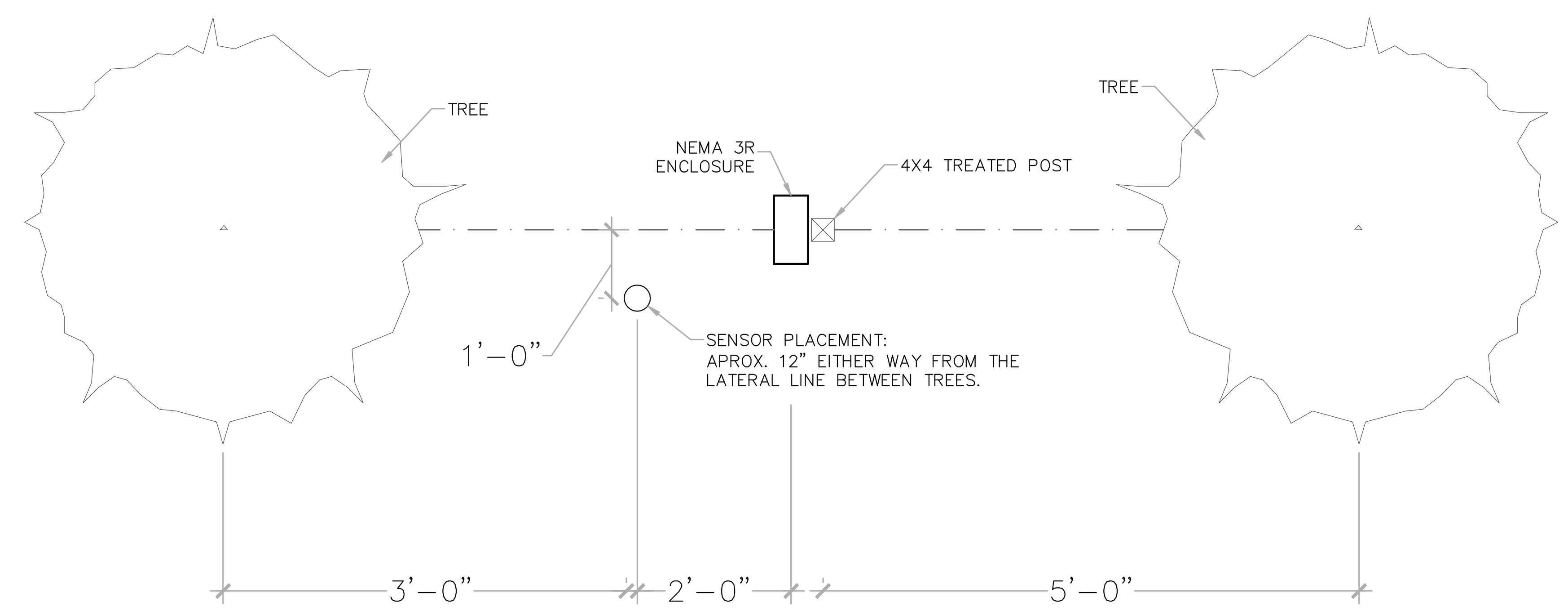
ZONE	ACRES
1	2.6
2	2.0
3	2.0
4	2.0
5	1.9
6	2.0
7	2.1
8	2.0
9	2.1
10	2.4
11	2.3
12	2.1
13	2.0
14	1.8
15	2.1



MeasureTek 4982 Willetta Street SW Albany, OR, 97321	**MESURETEK**	NO.
	FOR: SEABOARD GROUP II & CITY OF HIGHPOINT	IRR-1
DRAWN BY: Z EKSTROM / DATE: 08/31/2010		
DESIGNED BY: R HIBBS / SCALE : 1" = 120'	TITLE: IRRIGATION MONITORING LAYOUT	

Inset 2 - Sensor Placement

top view



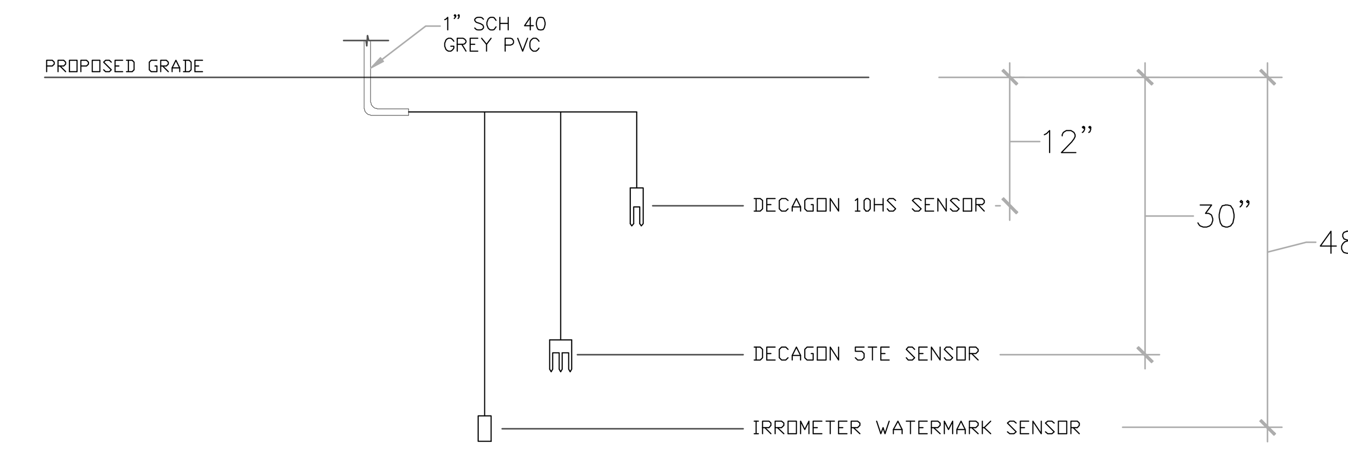
Soil Moisture - Conductivity Sensor Installation

INSTALLATION – 10HS/5TE SENSORS

- AUGER 4" HOLE VERTICALLY TO DESIRED DEPTH
- WET SOIL HOLE
- GENTLY PUSH SENSOR INTO BOTTOM OF HOLE WITH SLOTTED PVC PIPE
- ENSURE GOOD SOIL/ SENSOR CONTACT
- BACK FILL HOLE, TAMPING EVERY 6"
- AVOID AIR POCKETS, BUT DO NOT COMPACT SOIL EXCESSIVELY
- ROUTE WIRES TO BOX, ALL ABOVE GROUND WIRES TO BE ENCLOSED IN CONDUIT

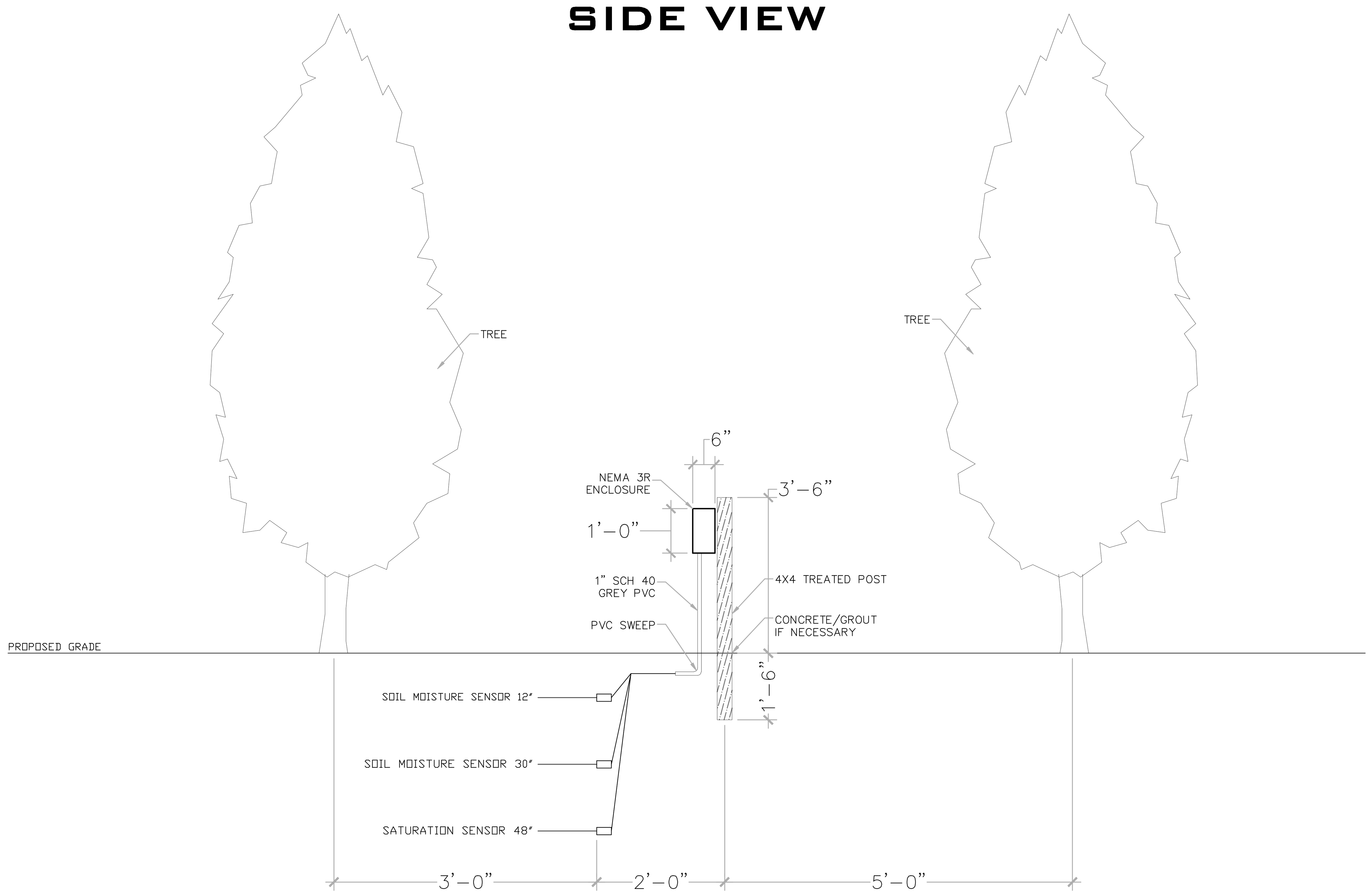
WATERMARK SENSOR INSTALLATION

- SOAK THE SENSORS OVERNIGHT IN A BUCKET OF WATER. ALWAYS PLANT A WET SENSOR. IF TIME PERMITS, ALLOW THE SENSOR TO DRY FOR ONE DAY AND REPEAT.
- LABEL THE ENDS OF THE WIRE WITH DEPTH/ LOCATION
- AT THE SITE, MIX A SLURRY OF FILL MATERIAL AND COAT THE SENSOR.
- AUGER A 1" HOLE TO THE DESIRED DEPTH
- PLACE THE SENSOR AT THE DESIRED DEPTH USING A SLOTTED PVC PIPE.
- USE DAMP SOIL BACK FILL AND TAMP OFF THE GROUND TO PROVIDE A GOOD SOIL/SET CONTACT
- AVOID AIR POCKETS, BUT DO NOT COMPACT SOIL EXCESSIVELY
- ROUTE WIRES TO BOX, ALL ABOVE GROUND WIRES TO BE ENCLOSED IN CONDUIT

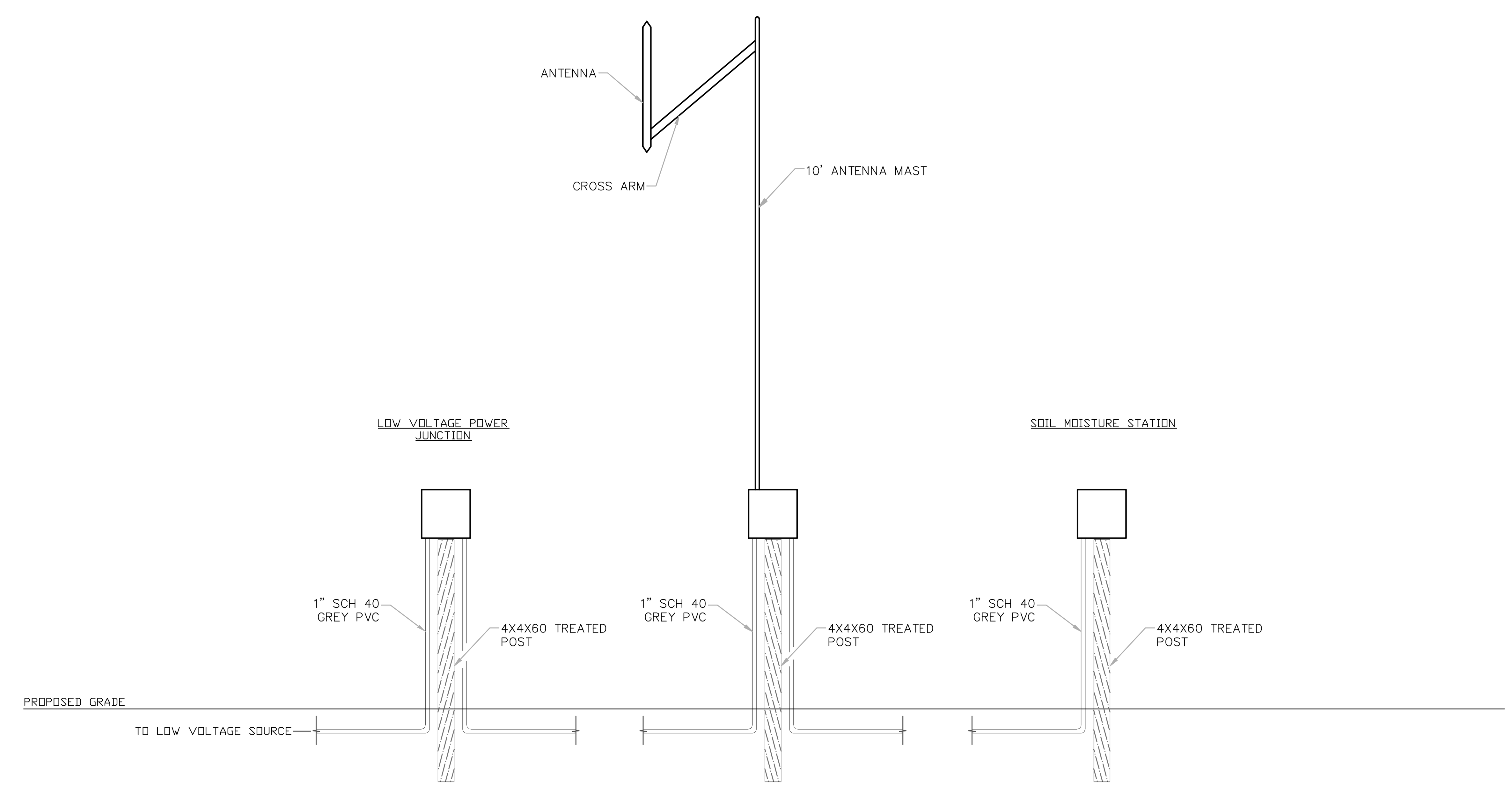


Inset 1 - Sensor & Junction Box Placement

side view



Soil Moisture Conductivity Station



MeasureTek
4982 Willetta Street SW
Albany, OR, 97321

MESURETEK

FOR: SEABOARD GROUP II & CITY OF HIGHPOINT

NO. IRR-2

DRAWN BY: Z EKSTROM

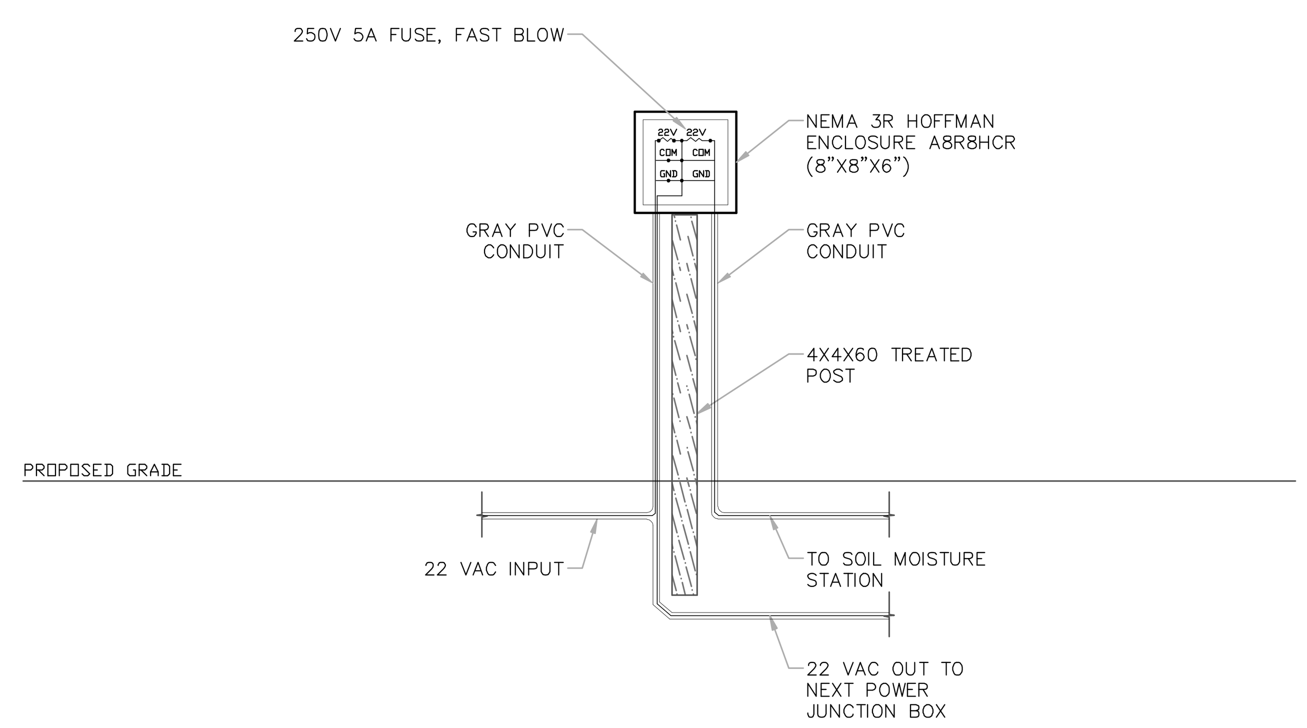
DESIGNED BY: R HIBBS

DATE: 08/31/2010

SCALE : ½" = 1'

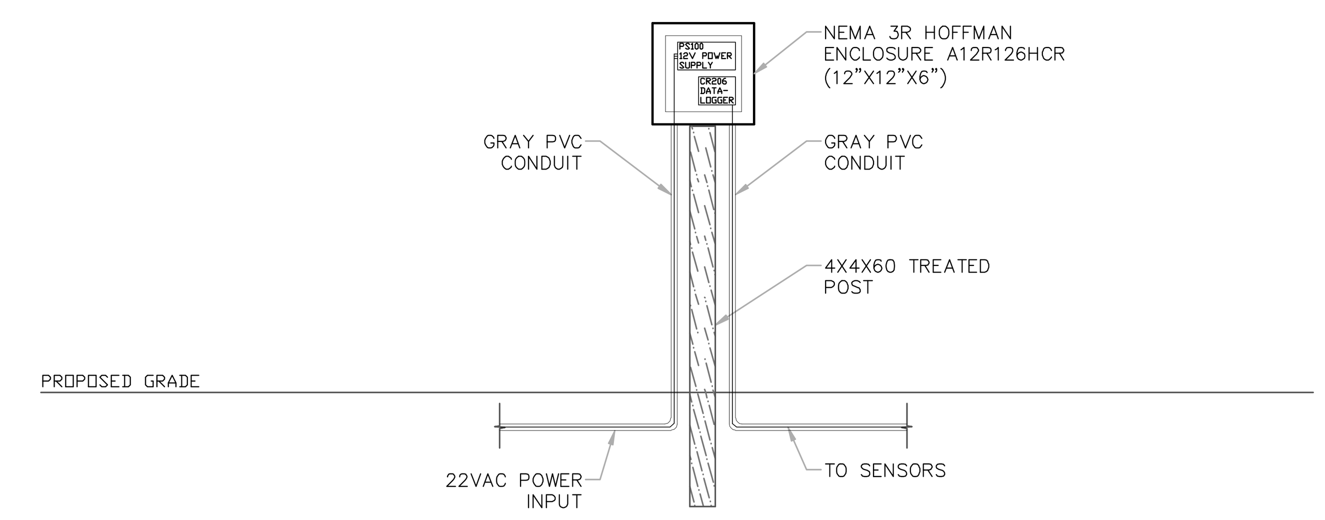
TITLE: SENSOR PLACEMENT

POWER JUNCTION BOX

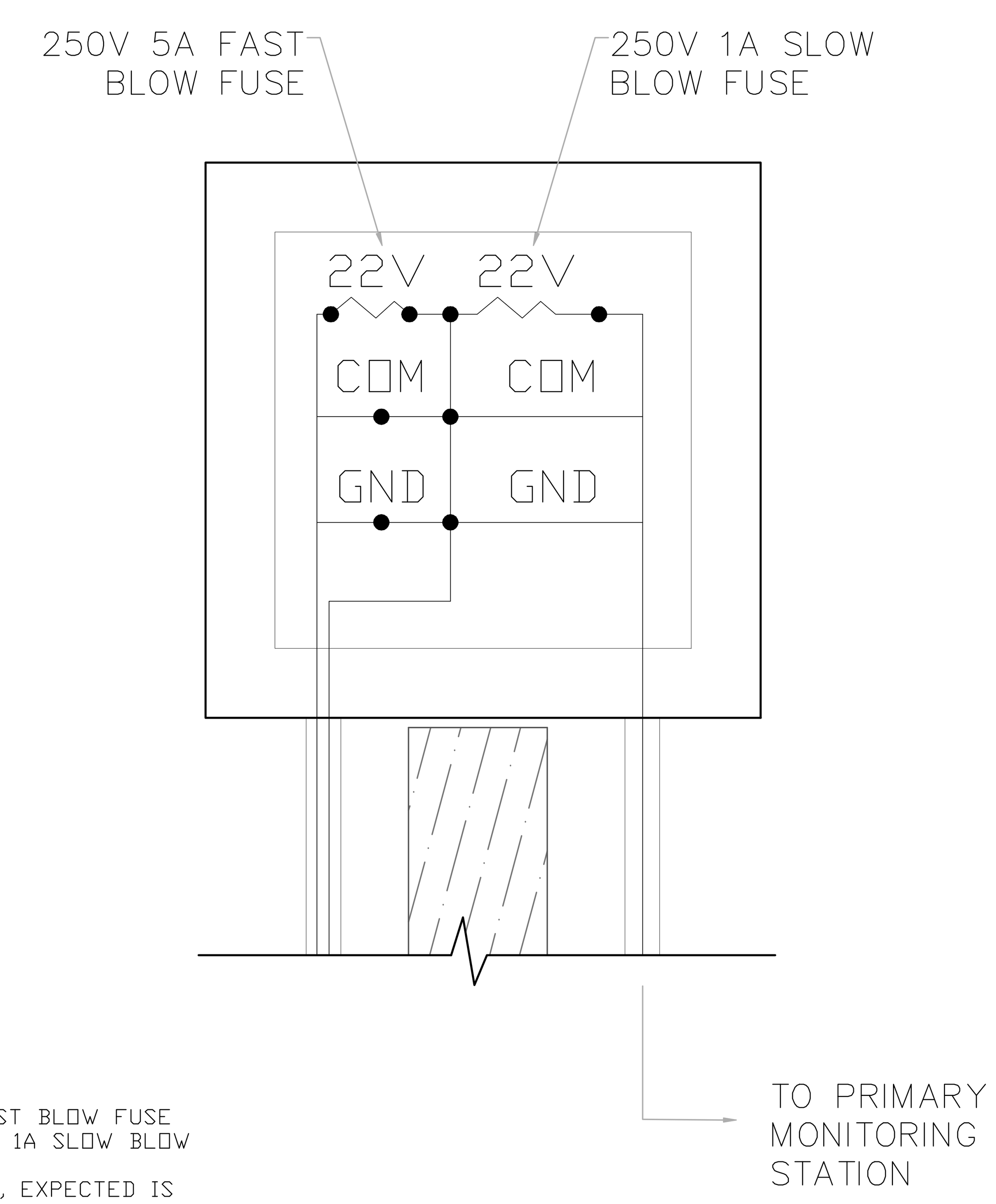


- INCOMING 22 VAC POWER FROM POWER SOURCE
- OUTGOING POWER TO SOIL MOISTURE STATION
- POWER MAY CONTINUE TO ANOTHER POWER JUNCTION BOX

PRIMARY MONITORING STATION



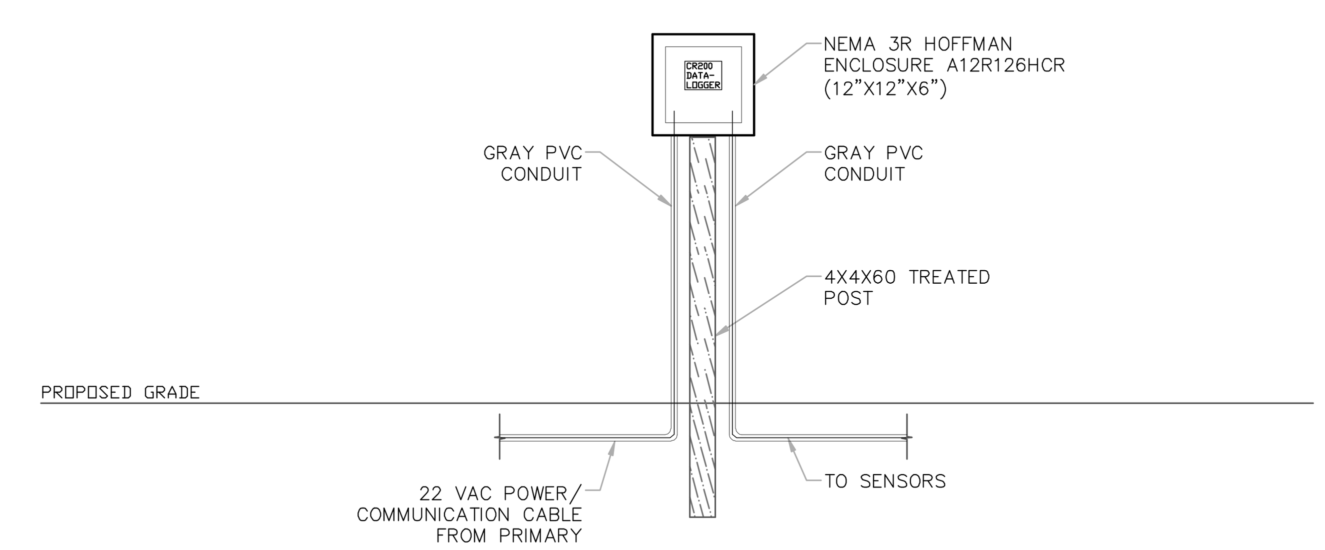
- MEASURES LOCAL SOIL MOISTURE/ CONDUCTIVITY
- RETRIEVES DATA FROM SECONDARY STATION VIA SDI-12 COMMUNICATION
- COMMUNICATE ALL DATA TO EITHER EAST LOBE REPEATER OR WEST LOBE REPEATER VIA RADIO



NOTES:

- INPUT VOLTAGE RANGE 14-22 VAC
- FUSE INPUT COLTAGE WITH 250V 5 AMP FAST BLOW FUSE
- FUSE STATION OUTPUT VOLTAGE WITH 250V 1A SLOW BLOW FUSE
- STATION'S MAXIMUM POWER USE IS 6 WATTS, EXPECTED IS LESS THAN 0.5 WATTS.

SECONDARY MONITORING STATION



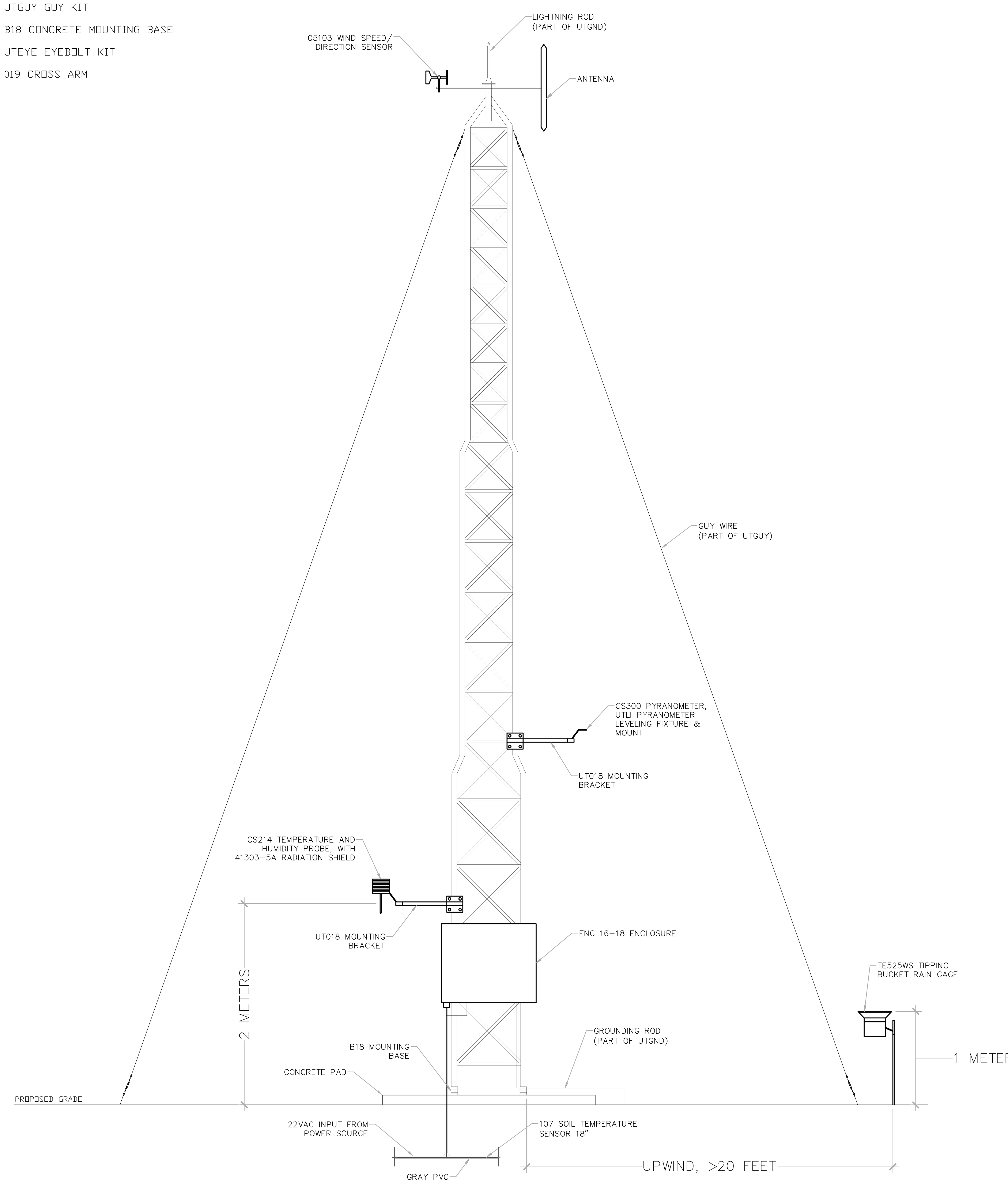
- MEASURES LOCAL SOIL MOISTURE/ CONDUCTIVITY
- SENDS DATA TO PRIMARY STATION VIA SDI-12 COMMUNICATION
- CONNECTS TO PRIMARY STATION VIA 4 CONDUCTOR, 18AWG SHIELDED, BURIAL CABLE INSTALLED IN SLIGHTLY BURIED
- (>4" DEPTH) 1" CONDUIT

MeasureTek 4982 Willetta Street SW Albany, OR, 97321	MESURETEK		NO.
	FOR:	SEABOARD GROUP II & CITY OF HIGHPOINT	IRR-3
DRAWN BY: Z EKSTROM DESIGNED BY: R HIBBS	DATE: 08/31/2010 SCALE : ½" = 1'	TITLE: MONITORING STATIONS	

WEATHER STATION AND EAST LOBE REPEATER ON 10 METER TOWER

REQUIRED COMPONENTS:

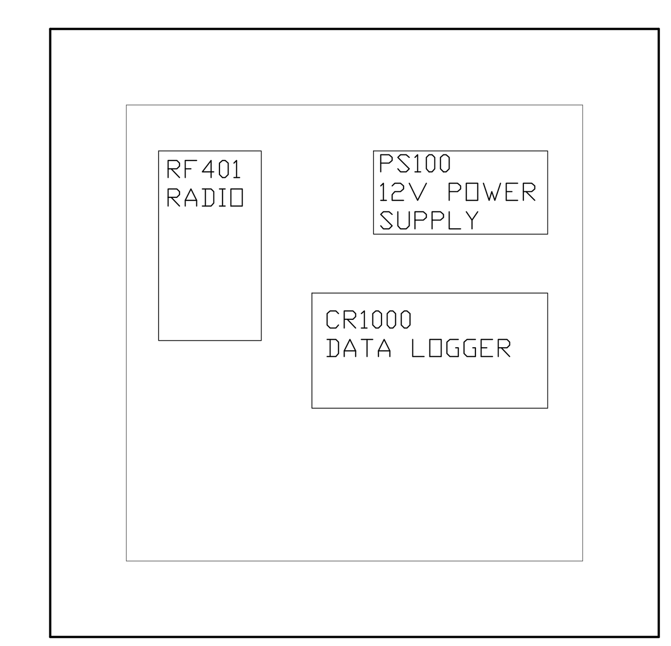
- UT30 TOWER
- UTGND GROUND KIT
- UTGUY GUY KIT
- B18 CONCRETE MOUNTING BASE
- UTEYE EYEBOLT KIT
- 019 CROSS ARM



WEATHER STATION/ EAST LOBE REPEATER NOTES:

- INSTALL UT30 TOWER ACCORDING TO MANUFACTURER SPECIFICATIONS WITH CONCRETE BASE AND GUY WIRES.
- INSTALL UT30 GROUND KIT, INCLUDING LIGHTNING ROD AND GROUND ROD.
- INSTALL TEMPERATURE AND HUMIDITY SENSOR AT 2 METER HEIGHT
- INSTALL WIND SPEED/ DIRECTION SENSOR AT 10 METER HEIGHT.
- INSTALL RAIN GAGE AT 1 METER HEIGHT, A MINIMUM OF 6 METERS UPWIND OF TOWER BASE.
- INSTALL SOIL TEMPERATURE SENSOR AT A DEPTH OF 18 INCHES.
- INSTALL ALL SENSORS ACCORDING TO MANUFACTURERS RECOMMENDATIONS.
- INSTALL OMNIDIRECTIONAL ANTENNA AT A HEIGHT OF 10 METERS.
- COMMUNICATION TO/ FROM THE WEATHER STATION IS VIA SPREAD SPECTRUM RADIO.
- 22VAC POWER COMES FROM A 22VAC POWER SOURCE
- DUAL PURPOSE WEATHER STATION AND EAST LOBE REPEATER STATION
- SERVES AS MAIN REPEATER FOR ALL STATIONS ON THE EAST LOBE

ENC 16/18 ENCLOSURE



MeasureTek
4982 Willetta Street SW
Albany, OR, 97321

MESURETEK

FOR: SEABOARD GROUP II & CITY OF HIGH POINT

NO. IRR-4

DRAWN BY: Z EKSTROM

DESIGNED BY: R HIBBS

DATE: 08/31/2010

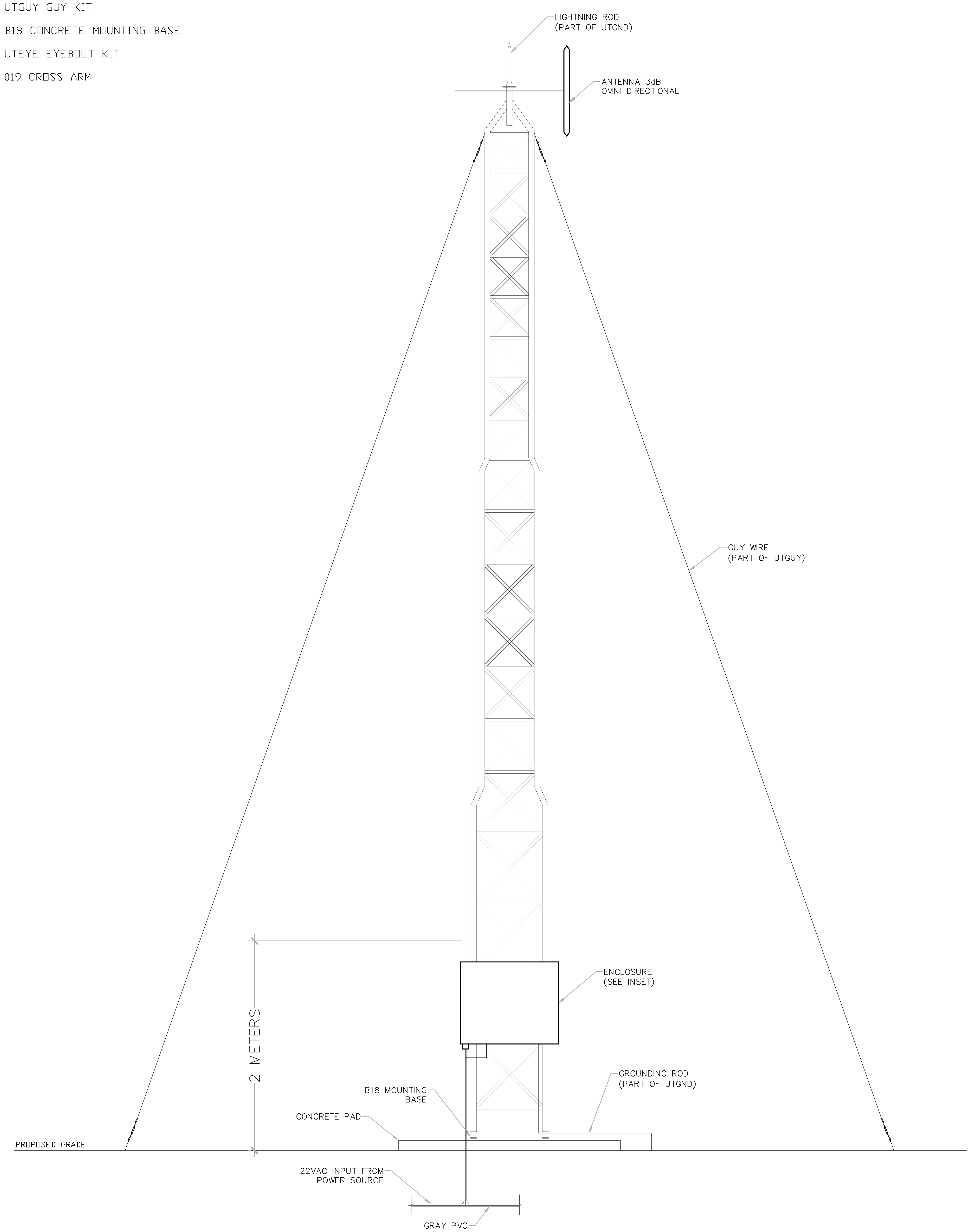
SCALE : ½" = 1'

TITLE: WEATHER STATION & EAST LOBE REPEATER STATION

WEST LOBE REPEATER & POWER SUPPLY STATION

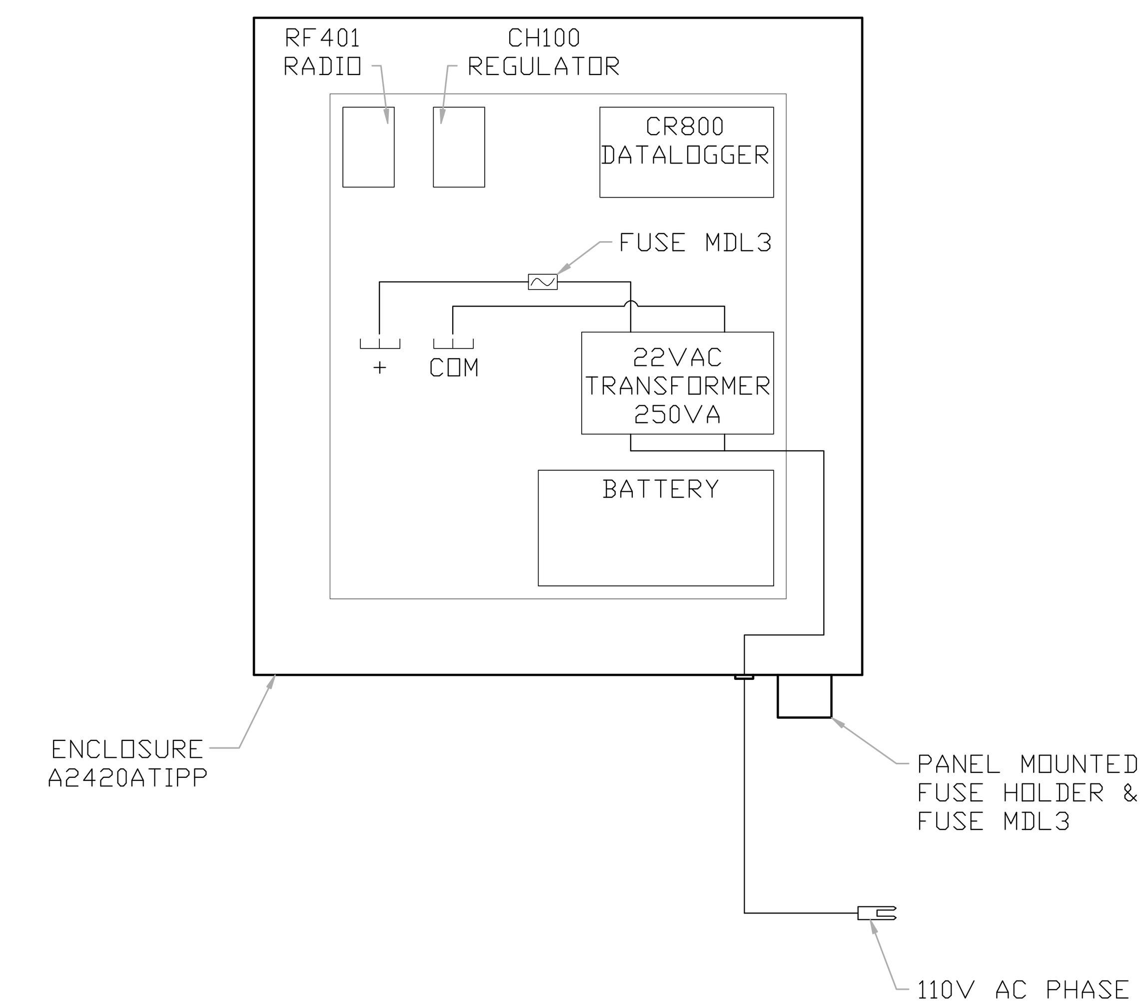
REQUIRED COMPONENTS:

- UT30 TOWER
- UTGND GROUND KIT
- UTGUY GUY KIT
- B18 CONCRETE MOUNTING BASE
- UTEYE EYEBOLT KIT
- 019 CROSS ARM



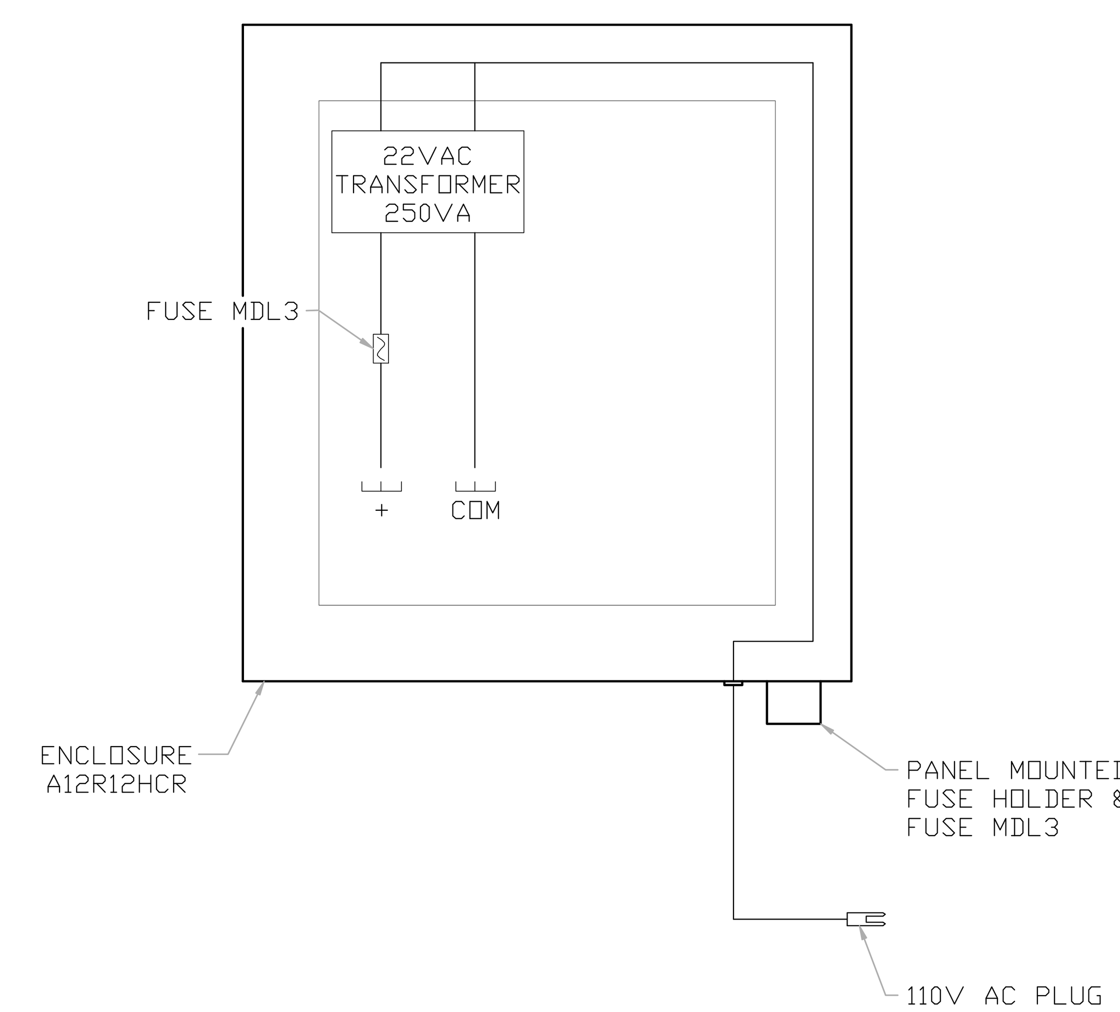
WEST LOBE REPEATER & POWER SUPPLY STATION NOTES:

- LOCATION TO BE NEAR, OR WITHIN, PSD PILOT PLOT LOCATION WHERE POWER IS AVAILABLE
- SUPPLIES POWER TO ALL WEST LOBE STATIONS
- RETRIEVES DATA FROM ALL WEST LOBE STATIONS VIA RADIO
- COMMUNICATION HUB/REPEATER BETWEEN MASTER STATION AND ALL WEST LOBE MONITORING STATIONS



MeasureTek 4982 Willetta Street SW Albany, OR, 97321	MESURETEK		NO.
	FOR:	SEABOARD GROUP II & CITY OF HIGH POINT	IRR-5
DRAWN BY: Z EKSTROM	DATE: 08/31/2010	TITLE:	WEST LOBE REPEATER & POWER SUPPLY STATION
DESIGNED BY: R HIBBS	SCALE : ½" = 1'		

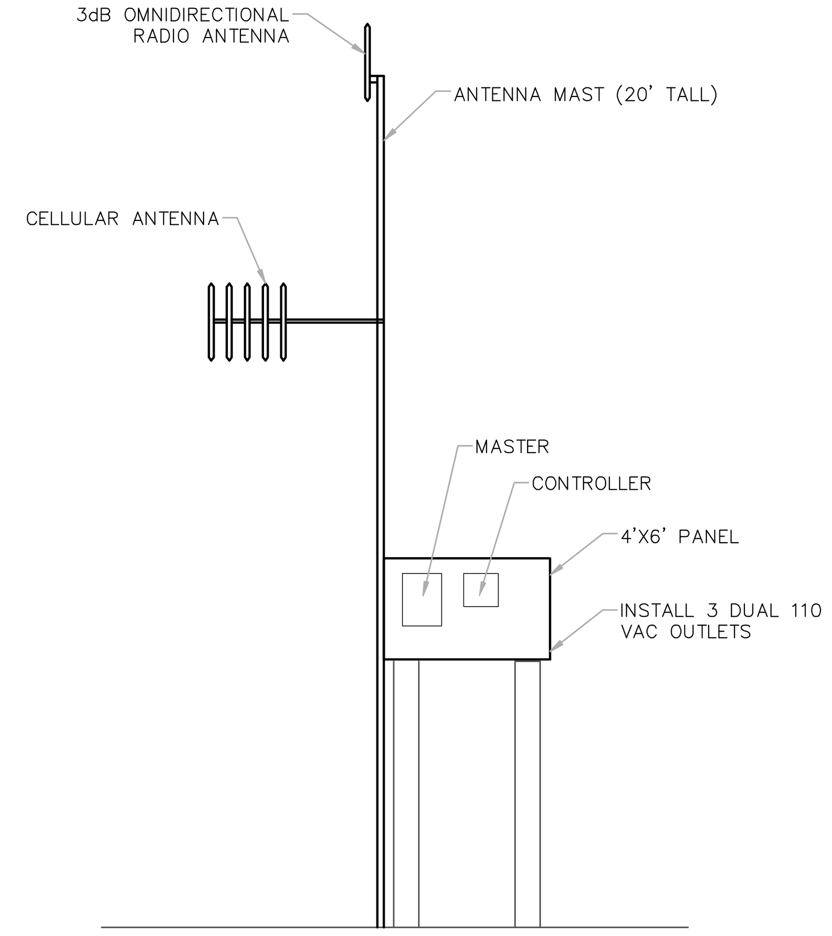
EAST LOBE POWER SUPPLY ENCLOSURE



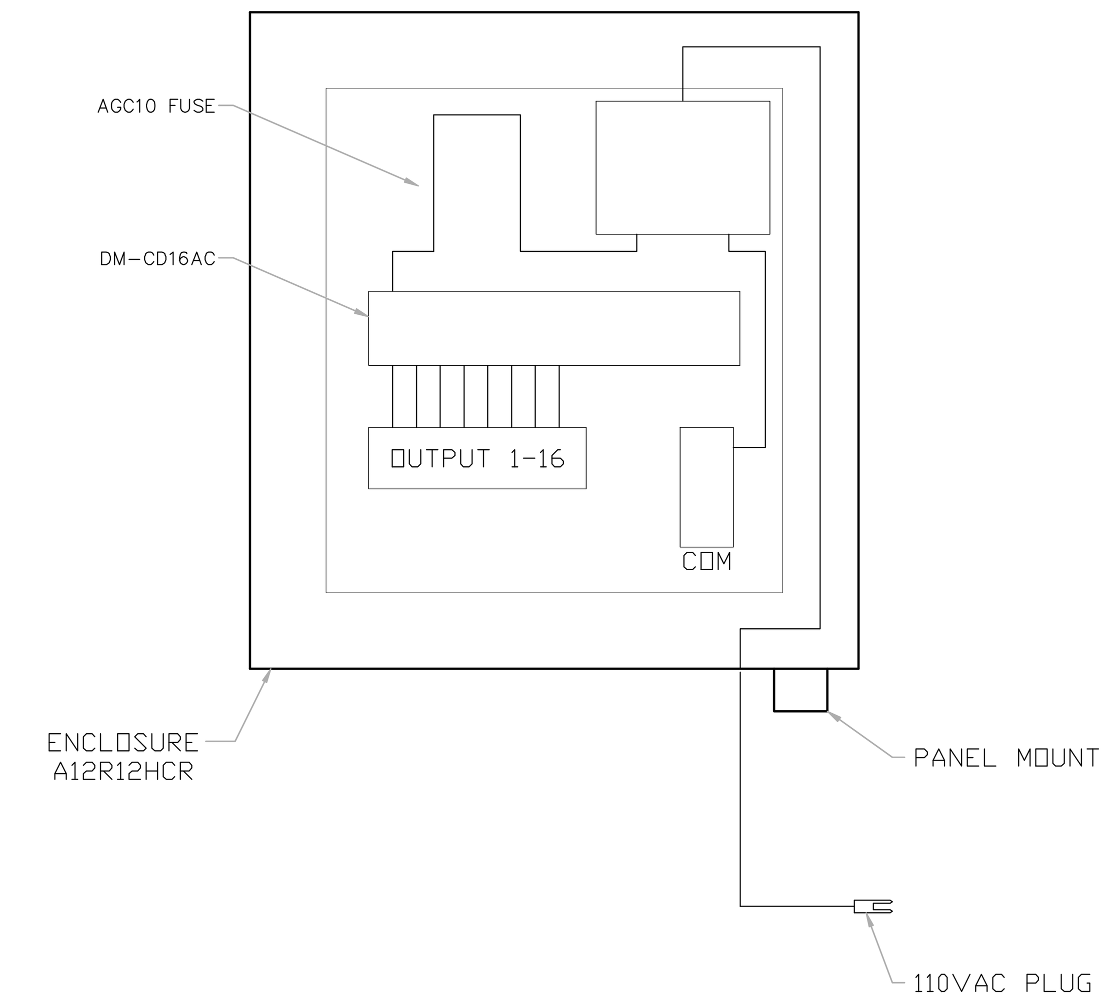
TO BE MOUNTED NEAR FENCE GATE ON EAST LOBE

	MeasureTek 4982 Willetta Street SW Albany, OR, 97321	MESURETEK	NO.
		FOR: SEABOARD GROUP II & CITY OF HIGH POINT	IRR-6
DRAWN BY: Z EKSTROM	DATE: 06/08/2010	TITLE: EAST LOBE POWER SUPPLY ENCLOSURE	
DESIGNED BY: R HIBBS	SCALE : ½" = 1'		

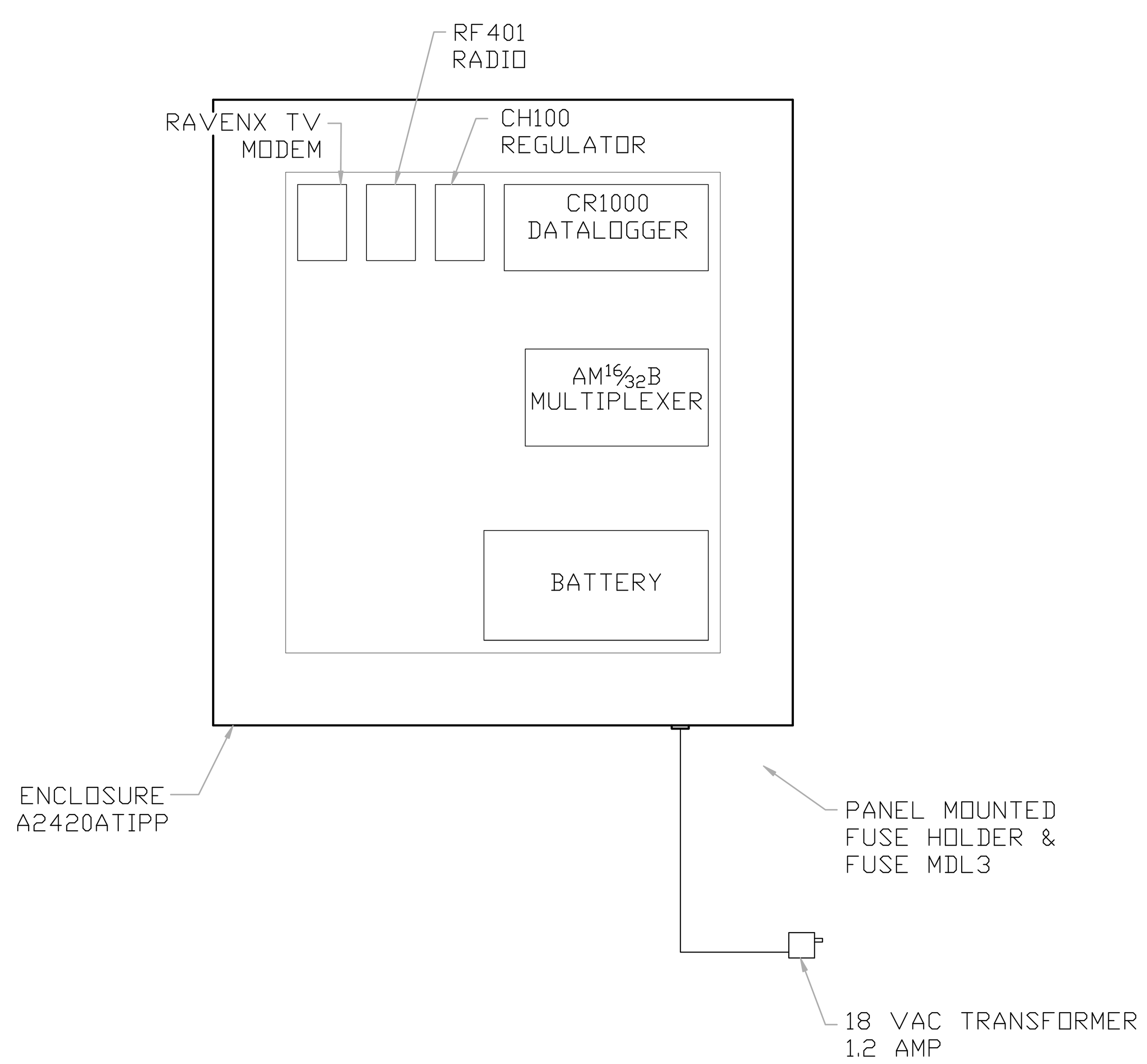
ENVIRONMENTAL BASE STATION



ENVIRONMENTAL BASE CONTROLLER



ENVIRONMENTAL BASE MASTER



MeasureTek 4982 Willetta Street SW Albany, OR, 97321	MESURETEK		NO.
	FOR:	SEABOARD GROUP II & CITY OF HIGH POINT	IRR-7
DRAWN BY: Z EKSTROM DESIGNED BY: R HIBBS	DATE: 08/31/2010 SCALE : ½" = 1'	TITLE: IRRIGATION MONITORING BASE STATION	